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OF

# Ceramic Ware

COLORING AND DECORATION

OF

CERAMIC WARE

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With Notes and Additions by Alphonse Salvetat.

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PUBLISHER'S PREFACE.

The writings of Alexander Brongniart marked an epoch in ceramic literature and remain a standard classic to the present day. Brongniart was for many years director of the famous porcelain works at Sèvres, France, and, with the generosity of a true scientist, gave to the world the results of his great chemical knowledge as applied to ceramics, as well as the observations of his predecessors and colleagues.

Notwithstanding the excellence and the value of Brongniart's work and that, at least, two editions of it have been published in the German language, there has not, so far as we know, been any translation of it, or any considerable part of it, into English. This, which we now publish, is only a portion of the original volumes; the translation of it was commenced for the pages of the organ of the clay industries, Brick, and it is at the request of a large number of readers of that paper that it is issued in book form.

Although Alexander Brongniart and his successor Alphonse Salvétat have passed away, there is a modern character about their formulas making them superior to many of those published today. The distinguishing characteristic of ancient recipes, whether for medicine or for workshop practice, was complexity. The physician's prescription contained from ten to twenty, or more, ingredients, the idea being that nature would select what was suitable for the case, the workshop formula was nothing if not complicated, and many of the formulas for glazes that are still highly prized, are absurd in their repetition of similar ingredients as well as the introduction of some that are quite unnecessary. Brongniart, a profound chemist, rejected all that was superfluous, reduced his recipes to their simplest form and brought them, practically, to the present day methods of making the formulas agree, as nearly as possible, with the combining weights of the materials used.

While this work is of especial interest to decorators of ceramic ware, potters and glazed and enameled brickmakers, we believe that every worker in clay, in whatever line, will find in it information and suggestions of real worth.

Coloring and Decoration of Ceramic Ware.

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The different kinds of ceramic wares are very rarely without some kind of decoration, as a rule they exhibit various colored ornamentations, which, as much, perhaps, as their characteristics of shape, color, method of manufacture, etc., enable us to fix the epoch, or the place, in which the piece was made.

Although in some instances vases have been ornamented with common paints and organic colors, we will only treat here of those materials for coloring and decorating, which can, without destroying them, be fixed upon clay ware by the action of fire. They are fixed by vitrifaction, hence they are called vitrifiable colors and may be divided into 4 principal classes which we will consider separately.

The different materials are:

1. The vitrifiable colors.
2. Slips. Earthy material fixed by vitrifiable flux.
3. Metals in the metallic state.
4. Metallic lusters.

With the exception of some rare instances, of which we do not take any account, all pottery is decorated, either by vitrifiable colors, colors which vitrify upon the surface of pottery by means of a suitable and known degree of heat, or by means of colored earthy material fixed on the surface of the ware by a vitreous flux. All these colors should unite in themselves several indispensable qualities.

1. Be fusible at a given temperature without deteriorating. This excludes all volatile and organic colors.

2. Adhere strongly to the body upon which they are applied.

3. Preserve a vitreous appearance after firing.

4. Be unaffected by the action of water and damp atmosphere or of the gases contained in the air.

5. Have the same ratio of expansion as the ware upon which they are laid.

In addition they should possess other qualities, as a fusibility greater than that of the body or ware which they decorate, sometimes the difference between the fusibility of the glaze and of the color is considerable, as in the case of hard porcelain. In other cases this difference scarcely exists, as in the case of bone china and earthenware. This is a real advantage, as the color penetrates into the body, unites with it, and there is no risk of its peeling off.

The hardness of a color varies according to its composition. We should always make it hard enough to be able to stand the rubbing of any ordinarily hard body that is likely to come in contact with it.

Indestructibility is an essential and the colors should resist all chemical action. They should not be affected at all by any of the substances to which under ordinary conditions they are exposed, such as vegetable acids, hot fat or the sulphuretted hydrogen gas which eggs give off while cooking, or that may exist in the atmosphere.

The dilatibility of the colors as compared with the body upon which they are laid, is perhaps one of the most important of all points. We shall enter into the question at some length when discussing the question of the physical influences of the glazes upon the vitrifiable colors.

Decorative materials may be divided into four series:

1. The metallic oxides. These are the most numerous and the most important.

2. The series of mineral bodies employed in potteries for coloring. These contain earthy material, or have an earthy appearance, whether they are white or whether colored by metallic oxides. These colors are opaque and do not produce a glaze by themselves, but will, when covered with a suitable material, take a glaze. These are slips.

3. The metals. These are applied in the metallic state, and obtain their metallic brilliancy by burnishing or polishing.

4. Metallic lusters. These are the metals in a state of ex-

treme division, so fine that they sometimes give iridescent
color reflections.

THE PASTES, BODIES OR CERAMIC ARTICLES CAPABLE
OF BEING DECORATED BY VITRIFIABLE COLORS.

It was shown in our work upon pottery and clays that nearly
all clay wares are decorated, either by the materials above
named or, if the potter knew nothing of these materials or
the manner of using them, by rude modeling of ornament in
relief, and even by lines and scratches symmetrically arranged.

A slight review of pottery in general, for the purpose of
noting the kind of decoration applied to it, the colors with
which it is enriched and the coloring materials known at the
epoch at which it was made, will enable us to follow, step by
step, the progress of our art, from the most remote periods
of antiquity down to our own time and the rapid and prodigious
development of the last few years will enable us to appreciate
the services which chemistry has already rendered, and the
still greater services which it has yet to perform.

We will consider, in treating of each color, upon what ware
it can be applied, and what changes have to be made in it,
to render it suitable for each kind of ware, from terra-cotta
to porcelain.

All ceramic products can be decorated by vitrifiable colors,
however fusible the clay may be, for there is none that fuses
at less than a white heat, and there are glazes which will flow
at a dull red heat, but all pottery has not been decorated
by colors, not because the body of the ware could not receive
the color, but because few of the ancient inhabitants of Europe
and America knew how to prepare them. We will therefore
only include in the following list those kinds of clay ware in
which we know that examples exist of the use of color:

1. Terra-cotta.   The clay colored, but with non-vitrifiable
colors. Utensils sometimes glazed and ornamented with enam-
eled colors.

2. Luster pottery.   Alkaline and siliceous colors and unglazed
colored earths.

3. Glazed pottery.   Colors usually opaque by means of alum-
inous earths, or tin oxide on the lead glaze.

4. Enameled ware.   Vitrifiable colors in great variety but

of a special composition in order that they should not be affected by the lead in the enamel.

5. Fine earthenware. Vitrifiable colors in variety, but generally less brilliant in consequence of the presence of lead, borax, etc., in the transparent glaze.

6. Stoneware. The common colors in reddish brown, in the clay body itself, or in a ferruginous slip. The fine colors are varied, either enameled, or dark and heavy, when transparent.

7. Hard or true porcelain. Enriched in various ways by metals and lusters, and by colors which are most varied and bright, in consequence of the hard and translucid covering or glaze.

8 and 9. Soft porcelain (bone china). Enriched in various ways like the hard porcelain, but with colors prepared expressly to suit the vitro-plumbiferous nature of the soft glaze. The colors having less firmness and durability in consequence of the nature and softness of the glaze.

The bodies have a great influence upon the colors, but as this only comes into play during the burning, we will leave this subject for the present, and discuss it later under the head of the influence and effects of the fire.

THE CHEMICAL PREPARATION OF THE VITRIFIABLE COLORS AND METALS.

Colors.—We can group the colors in different ways according to the way in which we regard them, but it seems to us that that is best which takes account of the most important characteristic in them, and that is the heat to which they can be subjected without being damaged; that is to say, the temperatures which they can or must be subjected to in firing. We will therefore divide them into

Ordinary muffle, or soft colors.

Mean temperature, or hard colors.

High temperature colors.

The two first groups are used only on the glaze, over-glaze colors; the third are under-glaze colors, or are mixed with the glaze itself and must be able to sustain as great a heat as the glaze requires, without deterioration.

The colors of the two first groups differ but slightly in their qualities, but the third group demands special compositions.

Before describing the colors of these three groups and their

application to the different pastes or bodies, it is necessary
to understand the preparation of the elements which enter
into their composition. These are the metallic oxides and the
fluxes.

COMPOSITION AND PREPARATION OF VITRIFIABLE COLORS.

Success may always be obtained in the preparation of colors,
but this success depends upon the purity of the oxides and the
exact composition of the fluxes. On mixing the oxides and
fluxes, prepared in the manner about to be described, we must
be quite certain that the materials employed are always alike,
not only in their chemical composition, but in their molecular
condition. The latter being a matter to which, formerly, no
consideration whatever was given, but which we now know is
of the greatest importance. Thus the oxides of iron, chromium,
purple of Cassius, of gold, of platinum, etc., may be perfectly
pure and yet not give good results if they were precipitated
too rapidly, or from dissolutions that were too concentrated,
or if they were made hot, or cold, etc. We have, in fact, a mul-
titude of examples of the influence of such circumstances.

It is only by an attentive and reasoning study of the ma-
terials employed in the decoration of pottery, and considered
from this double point of view, that we can avoid wasteful
and troublesome mistakes and only in this way can we be cer-
tain of obtaining, with a given formula, a definite color.

To facilitate the study of colors regarded in this way we
must establish a distinction to which, as a rule, far too little
importance is attached.

Under the name of vitrifiable colors it is a common mistake
to confound the color itself with its flux. The two substances
are considered as capable of chemically uniting by fusion and
forming by this means a complete homogeneous body. In some
cases only is this true; thus the oxides of cobalt and of copper,
which are only colors in the state of silicates or of salts.
In all the others the contrary is the case. Chromium oxide and
iron oxide offer striking examples, where the flux is nothing
but a vehicle which envelopes the coloring principle and fixes
it to the body upon which it is applied.

This distinction being recognized, we can consider sepa-
rately, one after the other, the color properly so-called and its

flux, and make a separate study of the preparation of the coloring materials, the oxides, and of the making of the fusible materials or fluxes which cause the oxide to adhere or glaze on the surface of the bodies on which they are placed.

THE OXIDES.

The indispensable conditions which the coloring matters must fulfill limit very much the number of substances that we can use. These conditions or requirements we enumerated at the commencement, though there are others too that we have to take into account. When painting upon porcelain, and it is in this work that perfection is most desired, in the case of colors having to be mixed in order to produce an infinite variety of tints we must avoid all substances which at the temperature required for burning react upon each other. This still further limits the number of color materials upon which we can depend. At present the materials employed are among the simple oxides:

Oxide of chromium.

Oxide of iron.

Oxide of uranium.

Oxide of manganese.

Oxide of zinc.

Oxide of cobalt.

Oxide of antimony.

Oxide of copper.

Oxide of tin.

Oxide of iridium.

Among the oxides partly salts or mixed with earths:

Chromate of iron.

Chromate of baryta.

Chromate of lead.

Chloride of silver.

Purple of Cassius.

Umber earth.

Siena earth.

Red and yellow ochres.

As the preparation of these different materials exercises the greatest influence upon the quality of the colors, in the compositions of which they form part, we will describe in succession the preparation of each one, give explanations which will

enable a correct choice to be made among the various methods and state the qualities which the different oxides should have in order to be used with success.

PREPARATION OF THE OXIDES WHICH ENTER INTO THE COMPOSITION OF VITRIFIABLE COLORS.

Oxide of chromium.—Immediately upon the discovery of chromium and after the researches which made its principal characteristics known, endeavors were made to utilize its precious qualities in the arts; the fixity of its oxide made it suitable for use as a green ground color for high temperatures, a color which up to that time was altogether wanting. The Royal porcelain works at Sèvres was the first to use it for this in 1802. Since then it has been introduced in muffle colors and has almost entirely replaced the copper colors.

There are numerous processes by means of which the chemist can procure this oxide in perfect purity but they cannot all be used with equal advantage. Some are too expensive, others do not produce the oxide in a suitable form. In practice the processes are reduced to four and it is of these that we will speak:

I. The decomposition of bichromate of potash by fire.—By this process we get a green of a fine tint but difficult to use.

II. The decomposition of chromate of potash by boiling hydrochloric acid, alcohol being added afterward.—By treating chromate of potash with boiling, concentrated, hydrochloric acid, then adding a little alcohol to facilitate the reduction of the acid, we obtain a protochloride of chromium from which the chromium is precipitated in the state of hydrate of the protoxide. This is filtered, well washed in warm water and the jelly which separates from the liquid is calcined. In many cases this oxide can be employed to advantage for bluish greens and should have a certain quantity of oxide of cobalt added to it. The oxide thus prepared and still in the form of a jelly has oxide of cobalt, also in a gelatinous state, mixed with it, ground on a palette, then dried and sharply calcined. This has given us greens of a remarkable purity and brilliancy.

III. Decomposition of chromate of potash by means of sulphur.—If at a high temperature, we submit a mixture of 1 part of yellow chromate of potash and 2 parts of sulphur in a clay crucible or a procelain cup, the mass will melt and

form an oxide of chromium which is sometimes crystalline. It has mixed with it sulphate of potash and sulphide of potash. These are got rid of by washing in running water.

IV. Decomposition of chromate of mercury by fire.—The chromate of protoxide of mercury decomposes by heat, leaving a beautiful chromium oxide which is pulverulent and works freely, but the operation is somewhat uncertain. It is generally a success, particularly if we carefully wash the chromate of mercury in boiling water until the washing water is but slightly discolored.

Chromate of protoxide of mercury is prepared by precipitating a solution of protonitrate of mercury, somewhat acid, with a solution of a chromate of potash diluted with the largest possible quantity of water. On pouring the one solution into the other a red flocculent precipitate is immediately formed. This precipitate, washed with plenty of water, dried and calcined in a crucible placed in a porcelain kiln, produces a pure chrome oxide. The tint of which varies and we are not able to find the cause for this. This is a great imperfection in the process for we sometimes get a light oxide of a beautiful and pure green and at other times a heavier oxide of a very dark and dull green.

This is an expensive preparation and considerable economy may be effected by saving the mercury instead of allowing it to be driven off and lost by the heat. To do this it is distilled in a fire-clay retort with a large neck, so that the mercuric chromate can be easily put in and the chromium oxide taken out. In this way the retort can be used a great many times.

If, as is very commonly done, we leave a considerable excess of nitrate of mercury in the solution we get a pure chromate of protoxide of mercury, but we lose all the excess mercury. If, on the contrary, we add an excess of chromate of potash to the mercurial salt we throw down together the chromate of mercury, sub-nitrate of mercury and some manganate of mercury.

The sub-nitrate results from the action of water upon the mercurial salt. The manganate is due to the presence of manganese, of which a certain quantity is found in the same mine as the chrome and forms, on its deflagration with nitre, a manganate of potash. In this case the whole of the mercury is precipitated. There is no objection to precipitating with an excess of chromate of potash. The sub-nitrate of mercury

being decomposable by heat, disappears entirely. It can have no influence upon the chemical purity of the oxide. The only effect it can have is to make it thinner, which is a decided advantage.

As for the manganate of mercury, its decomposition by heat leaves as a residue an oxide of manganese which, provided it is not present in too large a quantity, will assist by its combination with the chrome oxide in the development of a fine green color, particularly for high-temperature colors for porcelain.

By working in this manner and calcining in a closed vessel we get the mercury back for further operations. But oxide of chromium, by whichever way it is prepared, does not always give a strictly green tint, but sometimes only a greenish brown.

PREPARATION OF OXIDE OF IRON.

Oxide of iron is one of the substances which play the most important part in the manufacture of vitrifiable colors. The variety of tints which it offers, either by itself or mixed with other oxides, their richness and strength, have brought it into general use. The oxide alone gives a red, brown, violet and a crowd of intermediary shades, sometimes a red, that is nearly carmine, or a lac-red. Mixed with the oxide of manganese, oxide of cobalt or oxide of zinc. it supplies us with gray, sepia-brown and yellow-brown. It is an essential in the composition of yellows, of which it varies their intensity, and to which it communicates the precious property of enabling them to be mixed with other colors, without causing them to disappear, or even to deteriorate.

Iron colors are durable and there is no risk in subjecting them to the temperature of a muffle kiln. They preserve the most delicate tints when properly prepared. Unfortunately this is not the case with the high temperature of porcelain kilns. At this temperature it is possible for the oxide of iron to completely disappear by combining with the silicate of the feldspar and changing to the condition of a silicate of protoxide of iron, which is nearly colorless.

If the quantity of oxide is increased, a dirty, reddish-brown color is the result, called a lac-brown, sometimes blackish and always blemished.

Oxide of iron is disseminated in great abundance in nature, but its composition is never sufficiently constant to permit of its being employed at once in painting with vitrifiable colors.

Ochres, umbers and sienna earths exhibit marked differences in regard to their composition and should not be used in the preparation of vitrifiable colors until numerous trials have determined their fusibility with fluxes and their colors when used.

It is by calcining sulphate of iron that we prepare iron oxide, whatever the desired tint may be and the color obtained depends solely upon the temperature to which it has been subjected and the rapidity to which it has been brought to that temperature.

The ferrous sulphate (green vitriol) is in the form of transparent rhomboidal prisms of a pale bluish-green color. Exposed to heat it melts in its water of crystallization and on losing this water, becomes reduced to the white, pulverulent, anhydrous ferrous sulphate. At a still higher temperature this salt decomposes, the acid is driven off and nothing remains but a red oxide of iron, ferric oxide $Fe_2 O_3$ to which the name of colcothar is given. It is by this means that oxide of iron is prepared for painting on porcelain.

The crystallized sulphate of iron contains dry sulphate of iron 58.14, water of crystallization 41.86; total 100.00. Berzelius has found 45 per cent of water, and Mitcherlich 44 per cent. The anhydrous sulphate contains sulphuric acid 53.29, ferrous oxide 46.71; total 100.00.

As the preparation of oxide of iron presents some difficulties, we will consider it carefully. We take good crystals of sulphate of iron (green vitriol) and wash them with a small quantity of water to get rid of any portions that may be already decomposed, and transformed into oxide. When the crystals are quite clean they are crushed and exposed for a long time to heat, which must not be strong enough to melt them in their water of crystallization. When all the water has been driven off, the white mass which remains after dessication is reduced to as fine a powder as possible, and this is spread out evenly and thinly on slabs for roasting or in large, flat porcelain capsules. We then by degrees, and as slowly as possible, bring the capsules to a red heat in a muffle, constantly watching the color of the oxide by taking out every few seconds a small quantity upon an iron rod or wire. When it has acquired the desired tint the fire is stopped and the muffle allowed to cool slowly.

Calcined in this manner the iron becomes first of a yellow-orange color, then a carmine-red, a lac-red and lastly violet.

As soon as the muffle is cold the oxide is taken out, washed in several changes of boiling water and dried.

Prepared in this way, we always obtain an unvarying composition of ferric oxide, mixed with traces of alumina, resulting from the decomposition of the sulphate; metallic iron 69.34, oxygen 30.66, total 100.00.

By this process we can only obtain red oxide, carmine-red, lac-red and violet. It cannot be used in the preparation of yellow-browns nor of ochre-yellows.

To get an oxide of iron suitable for the preparation of these colors we must have recourse to another process, which depends upon the spontaneous decomposition of ferrous sulphate by means of aërated water.

Ferrous sulphate (green vitriol) is placed in a jar with a very large excess of water and allowed to remain for two weeks, care being taken to stir it frequently. The sulphate decomposes and a yellowish deposit settles. When we see that this deposit does not increase, it is decanted and washed to get rid of the sulphuric acid and any undecomposed salt and the deposit is dried slowly by exposing it to the air.

If we only operate upon small quantities of the ferrous sulphate at a time, we can hasten the preparation by adding hot water to the solution, the elevation of temperature replaces the prolonged contact of the air. The deposit is identically the same in either case. It is not, as was formerly believed, a subsulphate of peroxide of iron. When brought to a red heat it gives up 27 per cent of water. Dissolved in hydrochloric acid a brown precipitate is formed on the addition of ammonia, but the solution does not give any precipitate with chloride of baryta.

For browns, grays and blacks it is better to use oxide of iron precipitated from its solution by ammonia, potash or soda.

There is one more observation to make. The tint of the oxide of iron and its properties vary, not only in consequence of the nature of the reagent employed to precipitate it, but also that of the acid used in dissolving it.

Salts of iron and vegetable acids, leaving, under the influence of heat, nothing but ferric oxide will probably give various tints of red oxide. Here is a subject for new investigations which will doubtless be advantageous to whoever undertakes them.

PREPARATION OF OXIDE OF URANIUM.

Oxide of uranium, when properly prepared, ought to give us a brilliant yellow-orange, which can only be obtained with difficulty by means of potassium antimoniate.

It is widely used in Germany, but in France there is a general opinion that this color will not mix; it is, therefore, reserved for grounds. As it is a fine color of which good use may be made, we give the details of the method for preparing it.

Uranium is extracted from pitch-blende, which latter is a mixture, in variable proportions, of oxide of uranium, galena, iron arsenite and suphide, sulphide and carbonate of copper. These minerals are usually found in a gangue, or matrix, of carbonate of lime, magnesia, or sometimes manganese.

There are several ways of obtaining a sufficiently pure oxide of uranium from this very composite mineral. We give the following as the most expeditious:

Pitchblende is first washed with water acidulated with hydrochloric acid, to get rid of the carbonates of lime, magnesia, etc., usually mixed with the mineral; it is then treated with ordinary nitric acid, in which it dissolves readily. The solution is evaporated nearly to dryness and redissolved in cold water. The brick-red, insoluble deposit contains sulphate of lead and a large quantity of iron in the shape of free peroxide or combined with arsenious acid. The solution is filtered and evaporated at a gentle heat. On cooling there appears a confused mass of yellow crystals of nitrate of uranium, impregnated with a syrup-like mother liquor. This is allowed to drain off and the crystals are dissolved in water for the purpose of re-crystallizing. The second formation of crystals produces elongated prisms, separated from each other. These are drained off and washed rapidly in water. This water should be saved for the purpose of dissolving the crude nitrate of uranium when preparing another lot. Lastly the refined crystals of nitrate of uranium are dissolved in water for the purpose of precipitating the oxide of uranium required for use. The mother liquor which has been drained off from the first crystallization of the nitrate of uranium contains a large quantity of salt. It is diluted with water and a current of hydrosulphuric acid passed through it to separate the sulphides of copper, lead and arsenic which precipitate. The liquor, after being filtered or decanted, is evaporated nearly to dryness. On adding cold water nitrate

of uranium dissolves, leaving a ferruginous deposit. The solution of uranium nitrate is treated as before described.

Having thus prepared a pure solution of nitrate of uranium, we pour ammonia into it, when oxide of uranium is thrown down; but the oxide retains a considerable proportion of the reagent which has precipitated it. The yellow deposit thus formed is washed, then dried. This is uranate of ammonia. This compound completely dissolves in bicarbonate of ammonia.

The yellow liquor is boiled and loses its carbonate of ammonia, which is the final product. Prepared in this manner we find it sold commercially under the name of yellow oxide of uranium, but it is very often adulterated by the addition of chalk or other harmful substances which spoil it for our purpose, and is it better to prepare it for one's self.

Instead of ammonia we can use potash or soda to precipitate the uranium. The oxide is then yellower and more fusible, but when prepared in this way it does not give such a good color for painting.

We have recommended that the solution of nitrate of uranium be evaporated to the point of crystallization and that the crystals thus obtained should be refined by re-crystallizing, but this refining may be omitted if the pitchblende contains only a small quantity of foreign matter, as in that case the iron and other oxides are precipitated on evaporation of the liquid to complete dryness in the state of insoluble arseniates, but it is advisable to refine the oxide of uranium prepared in this way. After precipitating it with ammonia, filter and wash it to get rid of the last trace of copper held in the solution by the excess of the reagent. The filtrate is then dissolved in bicarbonate of ammonia. This again is filtered and the clear liquid is brought to the boiling point. A yellow deposit is formed which is pure oxide of uranium. This is washed and obtained in the dry state by decanting or by filtration.

PREPARATION OF OXIDE OF MANGANESE.

Oxide of manganese offers a number of resources to the art of decorating ceramic products. For the tender porcelain of Sèvres it enters into the composition of violets and blacks; for hard porcelain it is still more extensively used and in the preparation of blacks it replaces, to advantage, oxide of cobalt,

which is more expensive as well as more difficult to prepare. Lastly, we can use it along with oxide of iron to get a very good brown in high temperature kilns.

In the manufacture of some glazes oxide of manganese is employed in the mineral state, to produce the brown tints seen on common earthenware glazed with oxide of lead. In this case the native peroxide or sesquioxide is used.

This oxide of manganese was also at one time employed for some of the colors for the tender porcelain of Sèvres.

It is in every respect desirable to use a pure oxide, the more so that the preparation of oxide of manganese is neither a long nor a costly operation.

The manganese mineral is first crushed, then treated with hydrochloric acid at a gentle heat.

When solution is complete and no more gas is given off, a large quantity of water is added, the clear liquor is decanted and liquor ammonia is poured in little by little, while constantly stirring, or instead of the liquor ammonia a dilute solution of potash. The precipitate is allowed to stand for some time; it is then well washed before separating it, either by filtering or decantation. It is then dried and calcined and is deutoxide of manganese. It consists of manganese 72.75, oxygen 27.25, in the form of a black powder, which is not altered by heat. Strong acids in a concentrated state completely dissolve it with the assistance of heat.

PREPARATION OF OXIDE OF ZINC.

Although zinc oxide is in itself colorless and does not give color to any of the fluxes, it has been found in practice to have such an advantageous effect upon the tints of the greater number of coloring materials that it is very largely used in porcelain painting, and we have found it of considerable value, also in the decoration of common earthenware.

Oxide of zinc enters into the composition of greens, yellows, yellow-browns and blues, and it is principally in the preparation of these colors that its remarkable properties, which theory was far from indicating, show all their influence.

Oxide of zinc is one of those bodies whose physical condition, quite independently of its chemical composition, develops qualities necessary for the beauty of certain colors. Unfortunately we do not possess a perfect knowledge of the circum-

stances under which the oxide of zinc is formed in the right state, and the process which seems to be the most suitable often gives us an oxide of bad quality.

We cannot attribute the faults which certain oxides possess to the presence of foreign bodies. The zinc of commerce is generally pure and contains only a small trace of iron. Analysis indicates only an insignificant difference in the compositions of oxides from zinc of different qualities. Although the chemical properties of oxide of zinc are the same, whatever its quality may be, this is not the case with the physical properties.

A bad oxide of zinc will be heavy, granulated, dense and friable. By using such an oxide, although it may be perfectly pure, cobalt blues will be dirty, and brown-yellows will be changed and lowered. A good oxide of zinc, on the other hand, is generally light and flaky, without any trace of grains. We say generally, because an oxide of zinc prepared by the combustion of the metal, though it is extremely light, does not give such good results as that prepared by the following method, which, in our opinion, is the best:

Commercial (pig) zinc is dissolved in nitric or hydrochloric acid, nitric acid is preferable, arsenic is disengaged in the form of arseniuretted hydrogen. Manganese and iron dissolve along with the zinc, and the lead and copper remain as an insoluble powder.

When the dissolution is complete a large quantity of water is added, and while continually stirring, a dilute solution of carbonate of soda is added drop by drop. The first precipitate which is formed contains all the iron. This is thrown away. Then, as slowly and cautiously as before, more carbonate of soda solution is dropped in until the last addition of this reagent does not produce any more precipitate. The carbonate of zinc thus formed is allowed to settle; it is then decanted and washed. The carbonate is dried slowly at a temperature which must not be higher than 100 degrees C. (212 Fah.). It contains a certain fixed proportion of water. Its composition per 100 parts is as follows: Oxide of zinc, 73.0; carbonic acid, 14.9; water, 12.1. This preparation is rather expensive on account of nitric acid being used, but sulphuric acid may be employed instead and as this is much cheaper the result is more economical. If the attempts at using this have not hitherto been successful, it is because the hydrogen, which is disengaged, attacks the protoxide of iron, so that when the car-

bonate of soda solution is dropped in, the iron, instead of being thrown down first, is the last to be precipitated. We must, therefore, when the precipitation is complete, bring the iron back to the state of peroxide. This is easily done by heating the peroxide in a little nitric acid and then passing a current of chlorine through it. We then proceed as though the solution had been made in nitric acid.

Whichever method be adopted care must be taken that before dropping in the dilute solution of carbonate of soda, the acid solution itself must be diluted by the addition of the largest possible quantity of water. By observing this precaution we nearly always get a good oxide of zinc.

THE PREPARATION OF OXIDE OF COBALT.

Oxide of cobalt, which has been known for a great length of time is the one among all the oxides which produces the most beautiful and the strongest blue, and that can be applied to every ceramic material. It is to this oxide that the tender and hard porcelains, the finer and the coarse pottery, faience and different qualities of stoneware and many kinds of tiles, owe the rich and brilliant blue colors with which they are often decorated. It is one of the very few oxides whose color will stand in the highest temperature of a hard porcelain kiln. Oxide of cobalt is also used for the preparation of grays, blacks, blue-greens, etc.

Oxide of cobalt is prepared on a large scale by a process which, although it does not give an oxide that is chemically pure, appears to have been sufficiently so up to the present. The Sèvres blues, which have such a great reputation, have all been made with oxide prepared in this way, and we think it may be useful to publish the method.

The cobalt ore is reduced to a very fine powder. This is spread over a porcelain slab, which is covered with a little sand, to prevent the adherence of the mineral. It is then placed in the sharp fire of a kiln for hard porcelain. By this operation, which may be considered a complete roasting, all the sulphur is driven off as well as a large portion of the arsenic, the mineral becomes completely oxidized and closely compacted. It is again crushed in a mortar, as finely as possible, and then dissolved in nitric acid. In this solution successive precipitations are made by means of potash. We first precipitate the oxide and arseniate of iron, which have a yel-

lowish or whitish color. When the precipitate changes color and becomes pink or blue it is proof that all the oxide of iron is precipitated, and that nothing remains but oxide of cobalt, if the precipitate is blue, but if it is of a slightly pink tint some arsenic acid remains.

The liquid is then decanted for the last time, and the whole of the oxide of cobalt is precipitated by means of an excess of potash. It is collected on a cloth, washed and again decanted.

By this process we obtain an oxide of cobalt which is pure, so far as other oxides are concerned, but which is not entirely free from arsenic. A little silica also remains. This cannot be separated except by evaporating the solution of the mineral in nitric acid to dryness, a troublesome operation, which is useless, as the presence of a little silica in the oxide of cobalt can be of no disadvantage in the use for which it is destined.

The principal defect in this method consists in the fact that the first precipitates, composed mostly of oxide of iron, contain, nevertheless a considerable quantity of oxide of cobalt, which is thus lost. The following analysis, made by Mr. Marignac at the laboratory of Sèvres upon four precipitates, which were obtained before reaching the pure oxide, puts this beyond a doubt.

Components.	First. Precipitate.	Second. Precipitate.	Third. Precipitate.	Fourth Precipitate.
Arsenic acid	54.28	54.30	38.43	49.14
Oxide of cobalt	7.66	20.40	31.63	48.52
Oxide of iron	22.60	5.52	10.01	0.72
Oxides of copper and lead	15.46	19.78	19.93	1.62
Total	100.00	100.00	100.00	100.00

The first precipitate was of a pale gray or whitish color. It was composed principally of arsenates of iron and lead.

The second was a gray blue, indicating the presence of oxide of cobalt and a considerable proportion of oxide of copper.

The third was yellowish gray, due to the fact that the proportion of arsenical acid was not strong enough to entirely neutralize the oxide of iron. It contained, besides, a good quantity of oxide of copper and of lead.

The fourth precipitate was of a pure rose color and consisted almost exclusively of arsenate of cobalt. The precipitate was not very abundant, and it was at this stage that the precipitation was stopped, as the appearance indicated that only the cobalt remained in the solution.

Oxide of cobalt, prepared in this way, contains nothing else than arsenic and a little silica, but the proportions of these elements vary, and it is this variation of the composition which necessitates making some empirical trials when mixing a color with newly prepared oxide.

$$\left.\begin{array}{l} \text{Silica} \dots \dots \dots \dots \dots \dots \dots \dots \ 2.75 \\ \text{Arsenic acid} \dots \dots \dots \dots \dots \dots 17.10 \\ \text{Oxide of cobalt} \dots \dots \dots \dots \dots 80.15 \end{array}\right\} 100$$

M. Laurent found 66.50 of protoxide of cobalt and 26 of arsenic acid in an oxide used for high-fired blues, and in another preparation he found 70.00 of oxide of cobalt. Thus the oxide prepared in this way always contains arsenic acid in variable quantities. Although this acid is carried down with the iron in the first precipitates, a large proportion remains in the oxide which is found in the first deposits.

These two facts are due to one and the same cause, viz, the quantity of iron in the solution being too small. The solution contains both arsenate of iron and arsenate of cobalt, and when we neutralize it with potash, the two salts, being equally insoluble, are precipitated almost simultaneously, but as the oxide of iron is a weaker base, it has a tendency to be precipitated first. It is for this reason that the last precipitate is a nearly pure arsenate of cobalt.

The disadvantages we indicate above can be easily remedied, and we then get all the oxide of cobalt out of the mineral, and we obtain a more uniform degree of richness. This is done by adding a solution of iron in aqua regia (3 of muriatic to 1 of nitric acid) to the cobalt solution, before making any precipitate. The quantity of iron which must be added varies for each ore, but it is easy to determine the most suitable proportion for each case. After having dissolved the cobalt mineral in the acid, the solution of iron in aqua regia is poured in, a little at a time, a few drops of the solution are from time to time put in a glass and tested with potash. It can be seen when the precipitate which is formed exhibits a decidedly yellowish tint; this shows the presence of a slight excess of iron. We are then certain that we have added a sufficient quantity of the ferric solution. The remainder of the operation is carried out as described, without any modification.

In making the successive precipitations with the addition of potash, we obtain deposits, first of a whitish arsenate of iron,

then the yellow precipitate of oxide of iron, and lastly, when all the oxide of iron has been separated, we get the oxide of cobalt free from arsenic.

The first deposits are arsenate of iron, the last contains all the cobalt in the state of carbonate. It is important, in this case, to add a large excess of water when all the precipitate is formed, and to drop in the carbonate of potash with great caution. An excess of this reagent will disolve a large quantity of the carbonate of cobalt, because the carbonic acid liberated by the reaction will change the potash to bicarbonate, and this salt is a decided solvent for carbonate of cobalt. The addition of cold water determines the complete precipitation of all the carbonate of cobalt.

We prefer carbonate of potash to caustic potash, for. if the latter is used, when the oxide of cobalt is heated to drive off the water it absorbs a certain quantity of oxygen and becomes changed into a mixture of protoxide, and peroxide of varying proportions. Two successive preparations of an oxide rarely possess equal coloring properties, but we have not to fear this inconvenience with carbonate of cobalt. When washed and dried at a temperature of about 212 F. The water is dried off and the composition is always alike, if we take the precaution as before recommended, of first adding a solution of oxide of iron in aqua regia for the purpose of laying holdiof all the arsenic acid. It will then contain:

Oxide of cobalt........................69
Carbonic acid.........................31

A belief existed, based upon imperfect trials, that the presence of arsenic was essential for the production of a beautiful blue color. This is not the case; on the contrary, its presence is hurtful, because the arsenate so easily reduces to arsenide of cobalt.

For the purpose of comparison blues were made from

1. Pure oxide of cobalt.

2. Oxide of cobalt prepared by the Sèvres method. This oxide showed on analysis:

Oxide of cobalt..................80.15
Arsenic acid....................17.10
Silica 2.75

3. Arsenic of cobalt, prepared by dissolving pure oxide of

cobalt and precipating the solution with arsenate of potash,
washed and dried, the arsenate should contain:

> Oxide of cobalt..................53.15
> Arsenic acid.....................46.85

These materials were mixed with double their weight of flux
and passed through the kiln. The blues thus made were tried:
No. 1 was such a dark color that it looked black. No. 2 was a
fine blue. No. 3 was rather too pale. These trials at the time
appeared conclusive and the experimenters doubtless stopped
there, but they were not sufficient for us. The proportion of
flux was that generally used for an oxide prepared in the
ordinary manner, where all the arsenic is not removed. It
appeared to us reasonable to suppose that it would not be suffi-
cient to convert all the oxide of cobalt into silicate, on the other
hand it might be too strong for the arsenate of cobalt and
give a blue that was too pale. This was fully confirmed by
experiment.

To remove all doubt on this point test No. 1 was repeated,
but instead of mixing twice its weight of flux with the oxide of
cobalt three and a half times its weight was added; the
blue obtained in this way was more brilliant and in every
respect finer than that which was the result of the original test
No. 2, we have even obtained a fine blue from a mixture of 80
of flux and 20 of pure oxide of cobalt.

We cannot leave this important question of cobalt without
calling the attention of users of it to the great variation in the
percentage of the coloring principle contained in different
samples of cobalt mineral and of the necessity for testing it
before buying a large quantity. As a justification for this
remark we give below, in tabular form, analyses made at the
laboratory of Sèvres, of different purchases of the mineral.

Mineral crystallized......	33.64	3.52	1.43	43.37	17.88	Marignac.
Mineral in powder.........	28.16	4.86	2.57	42.17	21.58	Marignac.
Mineral in powder.........	20.71	8.04	14.60	38.99	15.66	Marignac.
Mixed with powder........	29.32	4.12	1.67	38.99	15.66	Marignac.
Amorphous mineral in						
large pieces..............	28.52	9.42	2.84	44.10	13.35	Marignac.
Amorphous mineral.......	18.00	9.42	2.84	44.10	13.35	Laurent.
Very pure mineral in						
large crystals............	44.70	trace	2.84	55.00	0.20	Salvètat.
Mineral less pure, in small						
crystals...................	37.10	5.00	2.66	48.10	7.00	Salvètat.

We also find on the market various sorts of oxide of cobalt and among these oxides some remarkable differences may be found. Some are cobalt in the state of carbonate, others are merely glass, more or less siliceous, colored with protoxide of cobalt. The first will effervescence and dissolve readily in nitric acid; the others are attacked with difficulty by acids and without effervescence.

M. Malaguti made an analysis of a sample of each of these varieties.

He found in one		In the other	
Cobalt protoxide	58.42	Cobalt protoxide	59.00
Silica	12.23	Silica	19.42
Water	11.94	Alumina	10.00
Carbonic acid and oxygen	11.00	Soda	10.06
Arsenic acid	3.14	Chalk, magnesia and loss.	1.00
Soluble salts	1.23	Peroxide of copper	0.51
Alumina	trace		

The latter oxide was combined with a flux and was of a red color, it was fusible and seen under the microscope had the appearance of a material that had been vitrified.

The first two of these oxides showed some resemblance to those of which we have given the composition and which are prepared by the ordinary methods used at Sèvres.

A more recent method of preparing oxide of cobalt is the following. For a number of years an oxide of cobalt was imported into France, which was exclusively used on account of the low price at which it was supplied, this oxide, which contains no other foreign matter than a little silica, has very high coloring properties and can be used at once, without further preparation, for a large number of colors, but for muffle blues it is necessary to change it to a carbonate; this is done with the greatest ease by dissolving it in boiling hydrochloric acid and then precipitating it with carbonate of soda.

The crude oxide of cobalt, as it was supplied by Evans & Askin, of Birmingham, England, was a by-product from the preparation of nickel. According to M. Louyet, the following was the method employed on a manufacturing scale to separate the two metals.

The mineral is mixed with a small quantity of lime and fluor-consisted principally of metallic sulpho-arsenides, and usually

contained 6 per cent of nickel and 3 per cent of cobalt, though these proportions are very variable.

The mineral is mixed with a small quantity of lime and fluorspar, the whole is then brought to a white heat in a reverberatory furnace; at this elevated temperature the mass melts and a fluid speiss of metallic appearance is formed, as also a scoria which floats upon it; this latter is skimmed off. The fluid mass is drawn out through an opening made in the furnace. It then has water poured over it to make it break up easily, and is broken into pieces. Experience proves that if the scoriæ presents a dull, or mat, appearance it contains iron; if, on the contrary, its surface is black and brilliant, there is no iron in it. The metallic mass is crushed and ground to a very fine powder and is then calcined at a bright red heat in a furnace. It is continually stirred and the heat is controlled so that the material does not melt. A large quantity of arsenious acid volatilizes. Air is allowed to have free access to the mass; it oxydizes and loses weight. The calcining lasts for about two hours and is continued until the white fumes cease to appear. The calcined residue is then treated with hydrochloric acid, which almost entirely dissolves it; the solution is diluted with water, then milk of lime and hypochlorite of lime are added; a precipitate is formed of iron and arsenic, which is thrown away. The hypochlorite of lime oxidizes the iron and facilitates its precipitation by the lime.

A current of washed hydrogen sulphide gas is then passed through the solution. The gas is made by means of sulphide of iron and dilute sulphuric acid. The solution is treated with the gas until it is saturated. The current of gas is stopped when, on adding liquor ammonia to a small quantity of the filtered solution, a black precipitate is formed. If there is no excess of the hydrogen sulphide the precipitate produced by the ammonia will be green. The hydrogen sulphide gas causes a precipitate in the solution; this must be washed and as it is rather soluble the wash water must be also treated with gas; this precipitate is then thrown away. We now throw down the cobalt by means of a solution of hypochlorite of lime. The precipitate is washed, dried and calcined at a red heat, it is considered to be a sesquioxide of cobalt and is put upon the market in this form; another portion of it is heated to a white heat. The oxide treated in this way loses in weight, but increases in density, and is sold as protoxide of cobalt.

The liquid from which the cobalt has been precipitated is treated with milk of lime, which precipitates the nickel in the condition of hydrate. This hydrate is washed, dried and calcined at a red heat, it is then mixed with charcoal and at a high temperature reduced to the state of metallic nickel.

The nickel is used for the manufacture of German silver; as for the cobalt, it is almost all used in the Staffordshire potteries and in glass works.

The oxide of cobalt prepared in this way is remarkably pure, it contains but very little nickel, and its price, considering its purity, is very low.

At Goerlitz, in Prussia, a very pure oxide of cobalt is prepared by calcination of a chemically pure nitrate of cobalt. The nitrate is made with chemically pure nitric acid acting upon chemically pure metallic cobalt; this is quite free from nickel, but it costs more than twice as much as the Birmingham oxide.

THE PREPARATION OF OXIDE OF ANTIMONY.

The use of oxide of antimony as a vitrifiable, yellow, coloring matter does not extend to a wayback epoch, the ancients probably had no knowledge of it; we have found only iron in the yellow vitrified materials which we have examined. We must, however, in this case too, make an exception in favor of the ancient Egyptians, who used it to color their enamels; giving an effect on a blue ground of alternate white and yellow streaks. The yellows, as M. Laurent supposed, being produced by antimony, which was proved by the analysis that we afterwards made.

With antimony we can get very fine yellow tints, varying from a pale sulphur yellow to orange yellow, by mixing it in suitable proportions, for the first, with oxide of zinc, for the second, with oxide of iron, but the orange yellows are not so bright, nor warm, as those obtained by the aid of uranium, or of chromate of lead.

The preparation of antimoniate of potash, which is the form in which we introduce it into vitrifiable matter, is not at all difficult.

We take metallic antimony, pulverize it with two and a half times its weight of crystallized nitrate of potash. A crucible is then brought to a red heat and the mixture of antimony and

saltpetre is thrown into it, a little at a time, the mixture vio-
lently ignites leaving a perfectly white residuum, which we
have nothing more to do to than wash in cold water. The resi-
due, according to Berzelius, is composed of a mixture of pot-
ash and nitrate of potash. This is washed to extract the ni-
trate. The remainder is a white powder consisting of,

Potash.. .... 12.25
Antimonic acid.... .... 87.75
                                         ———
                                         100.00

Some prefer, instead of antimoniate of potash melted with a
suitable flux and the addition of oxide of zinc, or oxide of iron
as required for the tint, to use the ready made composition,
known in commerce as Naples yellow. It is sufficient to grind
these yellows with their fluxes on a glass slab, when they are
at once ready for use, but as the commercial article varies very
much in its composition it is necessary, with each new sample,
to make a new trial and find the flux suitable to it, so that we
recommend the use of antimoniate of potash for yellow colors;
this we can prepare ourselves and use it according to the form-
ulas given later on.

PREPARATION OF OXIDE OF COPPER.

Copper is one of the substances frequently used and up to a
remote period, for coloring pottery. The Egyptians and the
Arabs, among the peoples of antiquity, employed it for their
blue and green glazes. The Chinese availed themselves of it
to obtain similar tints on their porcelains and it is to this
metal in one particular state of oxidation that they were in-
debted for their fine purples and reds which may be seen on
some of the red vases of Chinese origin and which have not yet
been successfully imitated in Europe.

Common earthenware, fine earthenware, tender porcelain and
stoneware, are colored green and blue by oxide of copper.

Copper forms, with oxygen, two different compounds, which
combined with silicic acid to form two compositions, the one
red and the other blue or green. It is always in the state of
silicate that the copper is colored.

Peroxide of copper is prepared in a pure state by a very
simple process. We dissolve the copper in nitric acid, evapo-

rate the solution to dryness, then sharply calcine the residue in a crucible. It is a black powder of dull appearance and is difficult to fuse. It is easily reduced by hydrogen and carbon.

Prepared in this way it is anhydrous and is composed of

```
Copper......  ........  ....  ..............  79.83
Oxygen......  ..  ......  .................  20.17
                                            ───────
                                            100.00
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The protoxide of copper is prepared in an entirely different manner. Several processes may be employed, but as they are all expensive and inconvenient we only give one; this is due to M. Malaguti and offers no difficulty for obtaining a fine product.

We melt together, at a gentle heat, 100 parts of sulphate of copper and 57 parts of crystallized carbonate of soda and the mass is heated until it solidifies. It is then pulverized and mixed with exactly 25 parts of copper filings, packed in crucibles and heated to a white heat; this temperature is kept up for about 20 minutes. After it is cooled it is pulverized and washed. The remainder is protoxide of copper, of a splendid red color and the finer the state of division of the material and the more it is washed the better the color.

Protoxide of copper is a red material, very fusible, if heated in contact with air it transforms into deutoxide and becomes black, it consists of

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Copper......  ....  ......  ..............  88.78
Oxygen........  ...  ....................  11.22
                                            ───────
                                            100.00
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PREPARATION OF OXIDE OF TIN.

Oxide of tin has long been known as giving a great opacity to transparent enamels. It is, therefore, an oxide which would naturally be used for whites both on earthenware and porcelain. It has also been used to give opacity to other vitrifiable colors, but it is not a coloring matter, it, in a measure, forms a part with the flux.

Oxide of tin may be prepared in a pure state by several methods. In practice only one has been adopted for the preparation of a suitable oxide, and this is never departed from. It is always used in the calcined state, that is to say intimately

mixed with oxide of lead. The operation is the same, whatever proportion the tin bears to the lead. The quantity of metallic lead which it is desired to oxodize is put into a roasting dish, which is brought to a red heat and when the lead is quite melted, the tin which is to form part of the calcination is weighed and is thrown into the molten lead, a little piece at a time. The mixture is stirred continuously, becomes oxidized and transformed into a pulverulent, or spongy, mass of dirty yellow color; it is a mixture of litharge and oxide of tin in such proportions as it is easy to determine before calcining them.

Instead of preparing oxide of tin in this way, some operators recommended the use of the white enamels which are found in commerce, and which need nothing more to be done to them than to be let down by melting them with lead and an alkali. It is true that these white enamels owe their opacity to oxide of tin, which is already in the condition of being white, but as they vary very much in their composition and often show great differences in their degrees of fusibility, it is only by means of long and troublesome trials that we can get a good and fine color by using them. It seems to us preferable to make the enamel oneself, using constant proportions of oxide of lead, oxide of tin and silica.

PREPARATION OF OXIDE OF IRIDIUM.

Oxide of iridium has only been used in vitrifiable painting for the last few years. The first trials were made of it in Germany; they were afterwards repeated in France and England. Metallic iridium gives us only a fine gray, but in the state of a sesquioxide it gives us blacks, which mix very much better than any other black known, whether obtained from oxides of iron and cobalt, or iron and manganese.

Several processes have been proposed for extracting iridium, or the sesquioxide of iridium, in a simple and economical manner, from the black residue which we get from the solution of platinum ore. This residue contains grains and metallic scales of osmiuret of iridium, and is very probably iridium in powder, with a very large quantity of titanate of iron.

Woehler was the first to work out a process for obtaining pure iridium. Persoz afterwards indicated another that was more technical, but Fremy published one which, better than any others, supplies an oxide of iridium free from osmium.

One hundred grams of the residue from platinum ore is mixed with 300 grams of saltpetre. The mixture is put into a large French clay crucible, and fired for one hour at a red heat in a blast furnace. After this calcination, the mass is run out on to a metal plate. This operation should be conducted in the open air, and it is even neccessary to cover the face, for without this precaution the vapors of osmic acid will have a serious effect upon the skin.

The decanted material containing the osmiate and iridiate of potash, is treated in a retort with nitric acid, which disengages the osmic acid.

The result of the distillation is washed, to get rid of the nitre, and then treated with hydrochloric acid, which dissolves the oxide of iridium.

The chloride of iridium thus formed has sal ammoniac added, when a reddish brown precipitate is thrown down; this is a result of the combination of the bichlorides of osmium and iridium with the sal ammoniac. To get rid of every trace of osmium we pass a current of sulphurous acid through these two double salts, while they are held in suspension in water; this dechlorizes the double salt of iridium, making it very soluble in water, while the double salt of osmium undergoes no change. The iridium, therefore, enters into solution, the osmium is precipitated in the shape of a red salt.

The filtered solution of iridium serves to prepare the sesqui-oxide of iridium. A current of chlorine causes it to reappear as a black and insoluble double salt. Calcined, this gives us metallic iridium, heated with two parts of carbonate of potash we get a perfectly pure sesquioxide of iridium.

Sesquioxide of iridium is a black powder, which does not decompose at a cherry red heat, but at a temperature above that of melting silver it parts with its oxygen; hydrogen gas reduces it without the assistance of heat; combustible bodies decompose it with a violent detonation. It consists of

> Iridium...... .... 89.16
> Oxygen.... ....,... 10.84
> ------
> 100.00

PREPARATION OF CHROMATE OF IRON.

The use of the chromate of protoxide of iron is sufficiently new to be known to but few ceramists; nevertheless it offers the

great advantage of supplying a fine brown color at a high temperature, even that of a hard porcelain sharp fire, which it would be impossible to obtain with oxide of iron.

To procure the chromate of protoxide of iron, neutral chromate of potash is dissolved in sufficient water, and into this is poured, a little at a time, an unchanged solution of protoxide of iron. The precipitate which is formed is gathered into a filter and well washed.

The exact composition of this precipitate is not yet known and the name, chromate of protoxide of iron, is perhaps incorrect. It may be that it is a combination of protoxide of chromium and sesquioxide of iron.

PREPARATION OF CHROMATE OF BARYTA.

Chromate of baryta, whose use was suggested by Godon, will give a very fine yellow on porcelain, but it requires a special flux.

Chromate of baryta is a canary-yellow colored salt, soluble in nitric acid, but very sparingly soluble in water. It is prepared, like the preceding salt, by pouring into a weak solution of neutral chromate of potash, an equally weak solution of a salt of baryta, until a precipitate is formed; this is filtered, or decanted off, and the precipitate is well washed with boiling water. Prepared in this manner chromate of baryta consists of

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Baryta  ................................59.88
Chromic acid...........................40.12
                                       _____
                                       100.00
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PREPARATION OF CHROMATE OF LEAD.

We find in commerce several varieties of chromate of lead, with different shades of color, from jonquil yellow to a deep orange yellow. These pigments, although very fine, cannot be advantageously used in the preparation of vitrified colors, as they nearly always contain, and in variable proportions, the sulphates of lime and of lead, which are added to make them brighter, but which hinder their fusion.

The analyses made in the laboratory of Sevres show too much variation in the composition of these commercial pigments to admit of their being relied upon: the chromate of lead varying from 17 to 25 per cent, sulphate of lime from 59 to 70 per cent,

sulphate of lead from 2 to 15, and sulphate of baryta from nothing to 15 per cent.

From these analyses we conclude that the preparation of a pure chromate of lead, the only kind which can be employed with success in vitrified colors, should be described here. It is obtained by decomposing the nitrate, or acetate, of lead, by chromate of potash. Two conditions are nevertheless necessary to obtain a suitable product.

1. It is essential that the chromate of potash be free from sulphate, which will precipitate sulphate of lead on mixing the lead with the chromate.

2. That the salt of lead shall contain neither iron nor copper.

In order that the nitrate, or acetate of lead shall be in a state of perfect purity, we take by preference Clichy white lead, free from sulphate of baryta, and dissolve it in nitric, or acetic acid. In default of pure white lead we may use litharge, but it should be carefully washed in pure water, in order to get rid of any dust lighter than oxide of lead. The solution is diluted with a large quantity of water, and sufficient chromate of potash is added until no further precipitate is formed. The precipitate is then washed in running water, and the yellow salt is dried by a gentle heat. It exhibits the fixed composition of neutral chromate of lead.

> Protoxide of lead.......................68.15
> Chromic acid 31.85
>
> 100.00

PREPARATION OF CHLORIDE OF SILVER.

Chloride of silver, by itself, is not used except for giving a yellow color to glass and crystal. In the vitrified colors it is confined to a few applications, but, as they are delicate, we think it well to enter into some details upon the subject of the precautions which must be taken in its preparation. Chloride of silver is only used for making carmines and gold purples; it does not enter into the composition of any color, but its qualities have an undeniable influence upon the richness and beauty of their tints.

The method which we have found, so far, the most successful, is as follows:

Metallic silver is taken, and for this purpose a coin may be

used; this is dissolved in nitric acid. When the solution is complete it is diluted with a large quantity of water, hydrochloric acid is then poured in, it is allowed to settle in the dark. The curdlike precipitate which is formed consists of pure chloride of silver. The copper in the coin, which is alloyed with the silver, remains in the liquid. When the chloride of silver is all settled at the bottom of the vessel the liquid is decanted off, water is added and again decanted, as the silver settles, this is repeated until the water which is poured off, on being tested with a solution of nitrate of silver, does not give a white precipitate or with yellow prussiate of potash a purple precipitate. Care must be taken that the silver is allowed to settle in the dark.

So long as copper is present, its existence will be shown by the yellow prussiate. Copper has the serious inconvenience of giving a dirty color. It is well to use distilled water, as far as possible, so as not to introduce into the carmine the lime which all ordinary waters contain.

When the reagents, nitrate of silver and prussiate of potash, no longer indicate the presence of hydrochloric acid, nor of copper, in the wash water, it is decanted for the last time and the chloride is dried by a gentle fire, wrapped up in filter paper to protect it from the action of light, which would blacken it. If it is not to be used at once it is well to keep it in a dark place. If this precaution is neglected it will be difficult to obtain pure and brilliant carmines and purples.

Prepared in this way, chloride of silver is pure and always presents the same molecular state, the same composition:

Chlorine	24.67
Silver	75.33
	100.00

PREPARATION OF PURPLE OF CASSIUS.

The name of purple of Cassius is given to a precipitate which is formed on adding a solution of gold to a mixture of solutions of protochloride and deutochloride of tin.

The importance of the rich and varied tints which this precipitate alone can give has, for a long time past, fixed upon it the attention of chemists, the unending resources which it offers to artists and above all to painters of flowers, and the

difficulties which must be overcome to obtain it in a suitable state, will be a sufficient justification for the full details which we give of its preparation.

Pure gold is dissolved in aqua regia, the composition of this varies with different authors, but further on will be found the receipts which have given us the best results. When the gold is dissolved the solution is diluted with water and filtered, then as large a quantity of water is added as possible. The solution must only be of a pale lemon color.

At the same time we prepare with great care—for it is upon this that the success of the operation depends—a solution of tin in aqua regia, to form at the one and the same time two different chlorides, the simultaneous presence of which is necessary to produce the purple precipitate.

Several indispensable conditions must be noted. Malacca tin is the best and is better if laminated, it is easier to divide into fragments. These are added one by one and dissolve spontaneously, leaving a slight black residue, which is separated by decantation, the solution should be made as slowly as possible. To retard the rapidity of the dissolution it is necessary to keep the acid in a cool place and only to add another piece of tin when that which has already been put in has disappeared. In this way we prevent the heating of the solution and its too rapid action.

The solution, being prepared in this way we pour the chlorides of tin into the lemon colored water containing the gold, this is done drop by drop, while stirring without ceasing; no fixed quantity of tin is used, but we stop as soon as the precipitate turns to violet.

The purple is allowed to settle and is then decanted several times, finally the precipitate is brought on to a filter, in order that it should get the consistency of a jelly. It is kept under water and when we use it we take, each time, just as much as we require.

All the authorities are agreed as to the importance of these precautions, but not as to the nature of the solvents, the proportions of these solvents relatively to the gold and the tin, the respective quantities of gold and of tin which it is well to use to get definite results, nor even as to the appearance, that is to say the color, which the purple should have to give bright and pure carmines.

At the manufactory of Sevres, P. Robert used for dissolving

the gold and the tin, an aqua regia composed of 4 parts by weight of nitric acid at 36 degrees strength and 1 part of hydrochlorate of ammonia.

It takes 30.59 grams of this aqua regia to dissolve 63 milligrams of fine gold and 22.94 grams of the same to dissolve 3.19 grams of pure Malacca tin. To the 22.94 grams of aqua regia for dissolving the tin, a little distilled water is added to make the solvent work slower. When all the tin is dissolved Mr. Robert adds to the solution an equal volume of pure water, he filters this and finally adds to it the solution of gold, which he first dilutes with so much water that it only has a straw color.

Mr. Buisson makes a neutral solution of protochloride of tin with one part of the metal in grains in hydrochloric acid, he then dissolves 2 parts of tin in an aqua regia consisting of 3 of nitric acid, of 36 degrees strength, and one of ordinary hydrochloric acid, finally he dissolves, with the aid of heat, 7 parts of fine gold in the exact quantity and no more, of aqua regia, sufficient for the purpose. The aqua regia is composed of 1 of nitric acid to 6 of hydrochloric. The solution of gold is diluted with 3½ liters of pure water; he adds to this the deutochloride of tin, and then pours in drop by drop, the protochloride of tin, until the precipitate is of the color of old wine.

At Sevres, Mr. Bunel dissolved 15 grams of tin in an aqua regia composed of 4 of nitric acid, one of hydrochloric acid and 10 parts of pure water. After the tin is dissolved it is diluted with 5 liters of water.

He then dissolves 5 grams of gold in aqua regia, so that there is no excess of acid and adds to the solution 5 liters of water, before pouring in the solution of tin, this is put in in very small quantities at a time, stirring all the while.

Mr. Bolley suggested a method of more easily obtaining a suitable mixture of protochloride and deutochloride of tin.

He takes 10 grams of pink salt (a salt containing 70 to 80 per cent of deutochloride of tin and 20 to 30 of chlorydrate of ammonia). This salt is anhydrous and always exhibits the same composition, to this is added 1.07 grams of metallic tin and 40 grams of water, this is heated until all the tin is dissolved. When solution is complete 140 grams of water is added, he uses this liquid to precipitate the solution of gold, which is prepared by treating 1.34 grams of gold with nitromuriatic acid, avoiding an excess of acid and after diluting it with 480 grams of pure water.

We now give the formula which has always, and in 5 hours, produced for us a fine purple.

At the moment of using it we prepare an aqua regia composed of 16.8 parts by weight of ordinary hydrochloric acid and 10.2 of nitric acid, 36 degrees strength. We dissolve a half gram of fine gold in 9 grams of this aqua regia and when the solution, which takes place spontaneously,is complete,we add 14 litres of water, thus diluted it shows but a pale yellow color.

At the same time we prepare 18 grams of a similar aqua regia, to which we add 3 or 5 grams of water, according to the temperature, in this we dissolve 3 grams of pure laminated tin, which we put in small portions at a time, keeping the vessel the while in a cool place. It takes 4 hours for the 3 grams of tin to be entirely dissolved, we then decant the clear part to separate it from the black deposit which is formed and we pour this solution, drop by drop, into the solution of gold. The purple precipitate which appears on agitating it, is washed with boiling water, it is of a fine old wine color.

By this process, where everything is weighed and measured, gold, tin, aqua regia and pure water, we have always, on observing the prescribed precautions, obtained precipitates giving good and beautiful colors, with the suitable fluxes, which we shall indicate further on.

Such are the various industrial processes by which the purple precipitate of cassius is produced. It is probable that all of these processes give precipitates with a similar coloring power, but which are far from being identical in their composition as is proved by the analysis made of this singular composition by chemists of undoubted ability.

PREPARATION OF OCHRE COLORS.

Numerous old receipts for the preparation of vitrifiable colors, show to what extent we can have recourse to natural colored minerals such as the ochres, yellow and red, the umbers and sienna earths. We do not entirely reject these, but we do not include them among our formulas for colors. We have applied ourselves, as much as possible to exact receipts, by the aid of which satisfactory results can be immediately arrived at and the ochres, umbers and sienna earths vary too much in their chemical composition for us to be able to obtain two similar compositions with them.

All the analyses that have been made indicate sufficiently the notable differences which exist in the elements of which they are composed.

Yellow ochre is a mixture of clay and of hydrated peroxide of iron, very rarely is it pure hydrate of peroxide of iron.

Red ochre is nothing else but yellow ochre calcined.

Umber is a hydrate of iron mixed with variable quantities of manganese oxide hydrate, soiled with a certain proportion of clay (there is here no question of bituminous earths).

Sienna is a product similar to umber, but containing less oxide of manganese.

The many analyses made at the laboratory of Sevres show that practice and trial in each case can alone tell us what flux and in what proportions, we must mix to get a good color.

As in some cases these natural substances can furnish tints, which it would be difficult to otherwise obtain, we give here the preparation to which they must be submitted before using them.

The crude earth is dissolved in water, made into a slum, this is decanted off and allowed to settle. The decantation separates the coarser grains. By settling, which takes place in pits, we get a paste, which is allowed to dry, it is then mixed with the quantity of flux, which preliminary tests have shown to be suitable and afterwards it is calcined, or not, according to the tint required.

FLUXES.

Fluxes are colorless vitrifiable matters which are added to metallic oxides or metals to make them adhere to a body and at the same time produce a glaze.

CONCERNING THE NATURE OF FLUXES.

If we turn our attention to the chemical nature of the various ceramic bodies upon which those coloring matters may be applied, whose preparation we have described, and if we consider that some of these melt at a temperature very nearly the same as that at which the color is fixed, while others, more hard, do not soften at all, therefore all the melting must be done by the flux. If further we note that the temperature at which the colors fire, varies with the nature of the product that we wish to decorate, and that the action of the different fusible agents should be different for each color element, it will be

easy to understand that, generally speaking, there must be very marked differences between all the fluxes. These depend upon the composition of the fusible matters that are used in their preparation, and upon the proportions in which we mix them.

Practical china decorators attribute, and probably with reason, a considerable influence to the fluxes upon the qualities of vitrifiable colors. Usually they complain very much more of the imperfection, or the little variety in the fluxes, than they do of imperfect preparation of the oxides and other elements of which we have treated.

The matters which enter into the composition of fluxes are:

1. Sand or quartz.
2. Feldspar.
3. Borax and boracic acid.
4. Nitrate of potash.
5. Carbonate of potash.
6. Carbonate of soda.
7. Minium and litharge.
8. Oxide of bismuth.

We have already spoken in our work upon clays and glazes of all these substances which enter, as fusible bodies, in the ceramic pastes and the glazes of these pastes, and will not repeat what we have said, though it is here, perhaps, more than anywhere, that we feel the influence of the slight variation of properties the cause probably entirely physical, has, so far, escaped the researches of scientific workers. We will, therefore, designate with as much preciseness as possible those materials which practice has adopted, distinguishing them from substances that would be harmful to use and which, from the point of view of chemistry, resemble them.

It is for this reason that we recommend the almost exclusive employment of sand from Etampes, in preference to that of Aumont, and of silica to furnish the fluxes with the silica which they must contain, although the most delicate chemical analysis fails to show any appreciable difference in the composition of these substances.

However varied may be the proportions in which we may combine the substances we have enumerated, to obtain compositions more or less fusible, the numerous conditions to which the vitrifiable colors, that is the oxides mixed with their fluxes, are subject, considerably limits the number of these fluxes.

If we remember that the finished colors, the colors ready for use, should adhere strongly to the body to which they are applied, that they should, in general, be more fusible than it is, that they should expand to about the same extent as it does, in order that, after firing, when the piece cools, crazing shall not result. All these qualities depending solely upon the fusible principle, it can be understood that there is not likely to be a large number of suitable fluxes.

The colors which serve to decorate any one body should admit of being mixed together, and this condition is above all indispensable for the painter on porcelain. Mixed in every proportion to produce the infinite variety of tints required by the artist, these colors should each preserve the tone which belongs to it, and this consideration will proscribe, or at least reserve for special and very rare cases, the employment of some of the oxides.

This same consideration may and should be applied to those fluxes whose energetic action has so much influence, as will be seen later, upon the shade and even upon the tint, which one and the same coloring principle may take. For instance, the presence of borax, of oxide of lead, or of sand, necessary to increase the richness of one color, will on the other hand oppose the development of tint in several others.

THE FLUXES, THEIR COMPOSITION AND PREPARATION.

Our study of fluxes is reduced to that of seven compositions, all employed as primary fusibles in the preparation of colors for hard porcelain and, with some slight modifications, in the colors for tender porcelain, fine faience and common earthenware, etc.

These principal fluxes are known in the vitrifiable color industry as.

No. 1. Rocaille.

No. 2. Flux for gray.

No. 3. Carmine flux.

No. 4. Purple flux.

No. 5. Violet flux.

No. 6. Green flux.

No. 7. Flux for gold and platinum in the metallic state.

It will be more frequently by their numbers than their names that we shall designate these.

No. 1 flux, rocaille, this is composed of:

Minium or litharge 75
Etampes sand 25

These two materials are well mixed and melted together in a
furnace which gives a good fire. They will, if the minium or
litharge used contains but very little copper, be found to be
converted into a yellowish-green mass. It is a silicate of
protoxide of lead, by calculation its composition would be,
Protoxide of lead 75, silica 25. Salvetat's analyses of a num-
ber of commercial samples of rocaille fluxes showed their aver-
age composition to be protoxide of lead 74.60, silica 25.40.

Some chemists melt the mixture of sand and minium in a
crucible, which they expose during the whole time of firing in
a hard porcelain kiln. When the kiln is drawn the crucible is
taken out and broken; this is a bad method. Exposed for a
long time to a high temperature, under the influence of moist
and reducing vapors, the mixture loses its oxide of lead and
becomes harder, in addition to this it is subject to the action
of the crucible, which gives up to it alumina and silica and
hardens it still more. The fusibility of the composition can
be preserved intact by melting it rapidly, and as soon as it is
melted, pouring it out on a metal plate.

No. 2 Gray flux:

Rocaille flux 88.88
Borax (calcined) 11.11
Minium, or litharge 66.66
Etampes sand 22.22
Borax (calcined) 11.11

The mixtures are melted together the same as the rocaille
flux, in a clay crucible, in a good furnace and poured out. The
remarks which we make upon flux No. 1, apply equally to
this.

On calculating the composition of this flux we find that it
should contain the following:

Protoxide of lead 66.66
Silica 22.22
Soda 3.40
Boracic acid 7.59

M. Malaguti found by actual analysis that it contained:

Protoxide of lead	66.40
Silica	22.46
Soda	3.40
Boracic acid	7.61
Lime, iron and alumina	0.13

This analysis confirms the synthesis given above.

Salvetat now makes use of a flux for grays, reds and yellows, etc.

No. 2. S., composed of:

Minium, or litharge	60
Sand from Etampes	15
Crystallized boracic acid	25

This gave on analysis:

Protoxide of lead	67.34
Silica	16.83
Anhydrous boracic acid	15.83

the 43.62 per cent of water which the boracic acid contains being deducted.

No. 3. Flux, for carmines; this flux is composed of:

Borax (calcined)	55.55
Etampes sand	33.33
Minium, or litharge	11.12

The mixture is melted like the preceding ones. If the carmine flux actually possesses this composition it ought to contain:

Boracic acid	38.36
Soda	17.20
Silica	33.33
Protoxide of lead	11.11

Analyses of a carmine flux in use for a long time at Sevres show that it contained:

Boracic acid	38.40
Soda	17.16
Silica	33.30
Protoxide of lead	11.00
Alumina, lime, etc.	0.14

These figures agree very well with the calculated composition.

The mixture of borax, sand and minium is melted in a clay crucible and poured out onto an iron plate like the preceding. It is recommended by some to pour it out into water, but this practice can only do harm, as the water will certainly dissolve out some of the borax and cannot improve the flux in any way.

No. 4, flux for purples. This flux employed by Salvetat is composed of:

Minium, or litharge	37.50
Etampes sand	12.50
Crystallized boracic acid	50.00

Anaylsis shows it to contain:

Protoxide of lead	47.96
Silica	15.98
Anhydrous boracic acid	36.06

It is melted and poured out in the same way as No. 2.

No. 5, flux for violet. Salvetat employs with advantage a violet flux, which renders the addition of a blue unnecessary. This is composed of:

Minium, or litharge	67.50
Etampes sand	5.00
Crystallized boracic acid	27.50

This is melted and poured out like No. 2, and contains:

Protoxide of lead	76.72
Silica	5.69
Anhydrous boracic acid	17.59

No. 6, flux for greens. Salvetat uses for this flux the composition.

Minium, or litharge	73.00
Etampes sand	9.00
Crystallized boracic acid	18.00

At Meissen, according to Kuehn, the formula for this flux is:

Minium, or litharge	73.00
Sand	18.00
Crystallized boracic acid	9.00

No. 7. Flux for metallic substances. This flux is nitrate of bismuth precipitated by water from its solution in nitric acid; it is white, slightly yellow. Care must be taken to avoid the addition of carbonate of potash, which some people add and

which will precipitate the oxides of nickel and copper that metallic bismuth often contains. The presence of a few thousandth parts, only, of copper, will prevent the gold showing a fine mat. We add to the oxide of bismuth one-twelfth of calcined borax and use, according to circumstances, from one-tenth to one-fifteenth of flux to one part of gold.

We have already said that the different oxides will not equally bear being subjected to a high temperature. From this come the essential distinctions between the vitrifiable colors.

Those colors which are not changed by the temperature necessary to make the varnish, enamel, or covering of the ware, run, are called high temperature, hard or underglaze colors. They are the less numerous in proportion to the glazes which have to be fired at a high heat. Beginning with the hardest colors, they are:

For hard porcelain, cobalt blue; chrome green; the browns of iron, manganese and of chromate of iron; the yellows obtained with oxide of titanium; uranium black.

To these we may add, as hard fire colors, but at a lower temperature for tender porcelain, the red and brown violets of manganese, of copper and of iron, which decorate some of the Chinese porcelains.

For fine and common faience, antimony yellows, manganese browns, copper greens and cobalt blues.

The colors which cannot support such a high temperature without undergoing great changes and which, for that reason, have to be fired, or partially melted, at a much lower heat than the preceding—the maximum of which is less than the fusing temperature of pure silver—bear the name of muffle colors, for porcelain and fine faience and of enamel colors for enameled ware.

It can be understood that there is in this series a possibility of having every tint for all kinds of paints and glazes.

The hard fire, or underglaze, colors have the great advantage over muffle colors that they do not soften when gold is fired on them. This consideration has induced a number of experiments, which have been completely successful, and have added to the palette a series having a much greater variety of tints than the underglaze colors; these are called hard muffle, or glost oven colors. They take a gloss in the muffle, but at a

much higher temperature than the colors for painting which are designated as tender, or light fire, muffle colors.

These colors, after they are fired, can receive other colors, burnished gold, platinizing, etc., without it being necessary, as with the tender colors, to remove the ground with the scraper, a troublesome operation, which makes gilding, or ornamenting, upon a ground of tender color, difficult and costly.

We may here treat more fully of the Chinese red colors, produced by copper, referred to above.

At Sevres I was able to reproduce the Chinese hard fire red, by means of two analyses, the one of a plain red, the other a flashed red, having the following compositions:

	Plain Red.	Flashed Red, Blue and Red, (Blue Drops.)
Silica	73.90	69.04
Alumina	6.00	4.00
Oxide of iron	7.30	3.84
Lime	7.30	12.00
Magnesia	trace.	trace.
Oxide of copper	4.60	0.24
Oxide of cobalt	0.00	1.50
Oxide of lead	trace.	0.70
Oxide of manganese	trace.	2.00
Potash	3.00	0.60
Soda	3.10	9.10
	100.00	100 00

The red and the blue enamels, which were analyzed, were submitted to several tests. The blue cover preserved its color under the blow-pipe both in the oxidizing and the reducing flame.

A fragment of a vase, with a red covering, was submitted to the sharp fire of one of the Sevres kilns. The red enamel suffered several alterations, depending upon its composition. It melted and ran together in beads in the hollows; ~it lost its red color entirely on the surface, becoming a pale green and opaline, but only partly in the interior, which remained here and there of a rose color, at points where the thickness of the layer had preserved it from oxidation during the firing.

The body, which was, before firing, perfectly white, took, when exposed to the influence of the kiln atmosphere, a very

pronounced brown color, due to the iron which this contained. The inside of the body, when a fresh surface was exposed by breakage, had preserved its original whiteness.

A fragment of the same vase was then fired in a muffle and brought to a red heat. Here no change whatever took place in the color and the corner of the fragment remained sharp.

The same fragment was then again tested, but this time the temperature was brought to that at which mat gold is fired. The heat was sufficient to soften the enamel a little and to slightly round off the sharpness of the broken corners, though not enough to cause the sand, in which the piece of vase had been placed, to adhere to it. Sevres hard porcelain, under similar conditions, would not have shown any change or softening.

From the preceding analysis and tests, we must conclude that the red color of the enamel is due to protoxide of copper in the covering glaze, that this covering fires at a very high temperature, although lower than that of the Sevres sharp fire, probably equal to the temperature of the sharp fire of the Chinese kilns, that the fusibility of this cover is increased by the proportion of lime, the quantity of which varies; its presence has been shown by both Ebelman and myself in all these covers of Chinese porcelain.

All the trials which I have made up to the present time have confirmed the above. In order to arrive at complete results, I have now only to determine the right conditions for firing pieces covered with red enamel. I should, however, add that I have not sought for the presence of oxide of tin in this color; it is possible that this may tend to fix the protoxide of copper and becomes the cause of the species of opacity which is seen in the Chinese red flashed with blue.

I have adopted as a formula for a red cover:

Aumont sand	38.00
Feldspar	50.00
Chalk	12.00
Peroxide of copper	6.00

Containing:

Silica	76.90
Alumina	7.75
Lime and magnesia	6.08
Potash and soda	3.72
Oxide of copper	6.00

In this formula we are compelled to exaggerate the quantity of coloring metal, the copper, in consequence of its volatilizing in a reducing atmosphere. This enamel is harder than the Chinese covering, but that condition is indispensable in order to prevent weeping. We ought even, to avoid more easily this defect, to compose the paste differently by making it more fusible—that is to say, by bringing it nearer to the composition of the Chinese porcelains.   We have found a mixture of 80 of standard paste and 20 of feldspar for cover to give fairly good results.

The standard paste is not suitable for pieces with a red covering; the smoking necessary to develop the coloring properties of copper, to bring it and keep it to the state of protoxide, is opposed to the usual conditions of firing, and the common paste is not easily burned. If we seek to make it transparent it must lose its red color and by the excess of heat the cover, even when hardened as we give the formula, will run and be spoiled.

By simply narrowing the chimney of a small kiln I have obtained red made with the soft paste; the cover did not weep, a thing that is rare, even on the pieces of Chinese manufacture.

I have deposited in the ceramic museum several samples of these trial pieces. On one of them a gold frieze, fired and burnished, has been placed. I do not know of a single piece from China that has received, on the red, either gold, or any other color.

Finally some samples of sharp-fire red porcelain, made at Sevres, reglazed with cobalt blue glass, showed violet and bluish tints similar to the flashed vases of China.

Since the early attempts I have made other trials, operating differently, first by way of reduction, where the copper was originally in the state of silicate of peroxide of copper; second, by plunging the fired porcelain into a bath of glass, colored red by protoxide of copper.

On closely examining the porcelains of China it is easy to believe that all three principles, which served as the basis of these different methods, were employed in that distant land.

TENDER, OR LIGHT-FIRE MUFFLE COLORS.

After the oxides on the one hand and the fluxes on the other, of which we have given the full details for their preparation,

are ready and these are not only sufficiently pure, but in a suitable state, we must make up the color and bring it into a fit condition for use.

We have already said that a vitrifiable color is composed of a flux, which fixes the color and at the same time forms a glaze on the body and a coloring oxide; therefore, to make a color, all we have to do is to add, in certain proportion, to the oxides or coloring principle, the flux which should make them adhere.

Sometimes, though only apparently, we go to work differently; it is true that the process we use is then more complicated, but there is a saving in time and money; it enables us to accomplish at one and the same time, two distinct operations, that is the preparation of the oxide coloring principle and the mixing of this with the fusible composition, which is to fix and gloss it.

Thus, if we put into a crucible some minium, sand, borax and potassium antimoniate, we at the same time get Naples yellow and a flux. We make them together, simultaneously; we could make them separately and then mix them, the color in each case would be equally fine and good. The first method is more economical and quicker; the second costs more and takes a longer time.

In workshop practice we reduce the labor of the preparation and make use of different methods, varying with the materials of which the color is composed.

Considered in relation to the processes used in their manufacture, colors may be divided into three groups.

The colors which do not melt, they are those which, like the colors furnished by oxide of iron, oxide of chrome, possess through each stage of preparation the same color they show in the finished ware, or those like the colors made from gold that will not bear a preliminary melting without changing; these oxides only mix with the fluxes.

The colors that melt are those in the composition of which oxides enter, that by themselves, have no color and only become colors in the condition of salts, that is to say in combination, either with silica, as cobalt and copper, or with lead, as antimony. The greens of copper, the blues of cobalt and the yellows of antimony are of this kind. We mix the oxides with the fluxes and melt at a certain temperature, depending in each case upon the color.

The colors which must be fritted are those which have not

the same tint when used; the oxide, as in the preceding case, does not retain its original color, but the melting point would be too high a temperature; this preliminary melting would change the tone which the color should have. The oxide is mixed with its flux and the temperature is gradually raised, but only just enough to soften the surface. The colors are about the most delicate to make.

This classification of the temperature at which the colors fire when applied to the goods, doubtless has its advantages, but it also has the inconvenience of separating, of dividing, the study of those colors which should be taken together; this causes frequent repetitions, which it seems to us could be avoided by grouping the colors according to their tints, no matter what is the method of their preparation. When treating a color we think it preferable to give all the formulas by which it can be produced, to render it suitable for use at one of the three principal temperatures that we have established.

We commence the study of a color by applying it, first, in a regular muffle fire; second, in a sharp muffle fire; third, in the sharp fire of a porcelain kiln, upon hard porcelain, tender porcelain, fine hard faience, fine common faience, etc., if the color is suitable for these applications.

Every color in use should be considered from two very important points of view: First the tint, tone or shade, which it ought to present after firing and which should be as nearly as possible like that which it has before firing; second, the property of being able to form with other suitable colors, mixtures which, in firing preserve, or take on the color we want.

This last quality, without which it would be impossible to have high art painting, depends solely upon the constant character and purity of the materials composing the colors and upon the correct determination of the proportions in which we mix these materials to make the colors. When colors mixed in certain proportions have once given, in a fire, within certain limits of temperature, a desired tint or shade, they will constantly do this. It is therefore only necessary to fulfill these conditions of purity, molecular state, and accurate proportions, and to this end the researches of the scientist and chemist should be directed.

Besides these two conditions, it is necessary that colors should possess a third—no less important—that is of taking a

glaze and of not peeling off when, laid on of a suitable thickness, they are fired at the right heat.

It is only the fritted colors that frequently exhibit marked differences in the tints of two different preparations; it is the degree of heat alone which gives them their tints, and we know how difficult that is to control. When a color of this kind does not show the required shade, it may be possible to correct it, either by the addition of colors, which, by their admixture, give the desired tint, or by the addition of colors made from the same recipe, but with a fault in the opposite direction; the first method should be rejected in every case where it is a question of a color to mix with others; it may be used, at most, for ground colors. The color corrected in this way loses its composition and it is upon its composition that its good qualities depend in mixtures. It can only be employed as a single color for grounds.

By the second process the properties of the colors are not altered; in this respect the composition remains identical, constant, and the color preserves its fundamental properties. This is a means which we have employed with advantage in most cases.

We will now give the details of the manufacture of each color and indicate the source of all the recipes and formulas which we present. Most of them have been tested in the laboratory of the Sevres works.

It will be seen that in several of these, ready-made colors enter as elements of the composition. As much as possible, we have replaced these quantities by suitable proportions of the materials which compose the colors themselves, so as to make the formula all of a piece, but in a number of cases, we must admit this was not possible, thus when a color, which can only be made at a high temperature, as yellow for instance, has to be used as the yellow vitrifiable principle in certain grays which can only be fritted.

WHITES.

No. 2. Permanent White (blanc fixe). This is the white enamel of commerce, the fusibility of which is increased or diminished by the addition of rocaille flux, No. 1, or of Etampes sand, to bring it to the suitable degree. It is almost impossible to give anything more definite than this, in consequence of

the variations which the commercial products present. We have tested several samples of white enamels that came from the same manufacturer and bore the same kind of label, but we found such marked differences between them that we had to abandon the endeavor to formulate a definite composition when using these commercial products. We give receipts suitable for making white enamel.

The following is according to the formula inscribed in the register of the royal works:

White Etampes sand	53
Calcine, formed of 15 tin to 100 lead	26
Carbonate of potash	21

The above was employed with success by M. Honore.

The materials are fritted together several times in succession, but only up to the point of fusion, and after well triturating the product from the preceding frit.

Messrs. Paris and Ami make a white enamel by melting together:

Calcined borax	14
Oxide of tin	14
Arsenious acid	4
Crystal C.	68

Crystal C is composed of:

White sand	45
Minium	37
Carbonate of potash	18

These are melted together.

This white serves to brighten the light portions of linen draperies and of white flowers which would not be lively enough if they were merely produced by the white surface of the porcelain. It also enables us to lighten the places that the artist may have omitted to leave in his sketch by laying a sufficient thickness upon any of the colors required.

No. 3. Gorge White. This is a name that was given at Sevres to a fusible composition which is added to those parts that could not take the cover necessary to glaze them in a sharp fire. It is made by taking:

Rocaille flux No. 1	50
Flux for carmine No. 3	50

These are ground together on a slab before use.

To be of a good quality it must be colorless. We must also be careful in the choice of the litharge, or minium, with which the Rocaille flux is made. If it contains copper the gorge white will not be of a fine white. It can be made more opaque by the addition of a small quantity of white enamel.

NO. 4 WHITE TO MIX WITH CHINESE WHITE.

This color is obtained by modifying permanent white No. 2 by the addition of flux No. 1

This serves for ornamentation in relief on white or colored grounds in the Chinese manner. M. Colville, was the first to do this and bring it to the greatest perfection.

This color should be capable of being mixed with every other color, giving it body and opacity without causing it to peel off, and serve the same purpose in vitrifiable colors that white lead does in oil painting.

It is upon the same principles and with the same elements that the whites for tender porcelain and fine and common faience must be made, both for sharp and muffle fires. The beautiful Parisian faiences with blue grounds show us examples of the application of these colors.

The whites which are laid on in relief in rustic pottery have no correspondence with this except in so far as the color is concerned. That used in the rustic pottery is an earth material, a white clay, which only adheres to the ware by the softening of the glaze upon which it is placed.

GRAY.

The grays are muffle colors, which are very liable to change at high temperatures, become black, dirty, lose their glaze and even completely disappear. We obtain these by means of an infinite variety of mixtures, or oxides of iron, of man ganese, of cobalt, with the addition of a sufficient quanity of flux.

The grays that are used at Sevres mix with other colors for giving tints which are often very delicate. In that respect they possess considerable importance, and are often very difficult to make in order to fulfil the different purposes for which figure painters principally use them.

NO. 12 DARK GRAY AND 12 P. F. DARK GRAY FOR GROUNDS.

	Bunel.	Salvetat.
Flux for gray No. 2 or 2S 68		88
Carbonate of cobalt 6		8
Yellow oxide of iron 13		4
Carbonate of zinc (hydrate) 13		..
	100	100

This is triturated together and melted at a low heat. To make No. 12 P. f. we increase the quantity of flux. The yellow oxide of iron used above is the hydrate of peroxide of iron, obtained by the decomposition of the sulphate of iron, by means of water. No. 12 is used in painting to change to a gray all the tints of the palette and to blend colors into the shadows.

NO. 13 REDDISH GRAY AND 13 P. F. REDDISH GRAY FOR GROUNDS.

Salvetat.	Bunel.
Flux for gray No. 2s 88	Flux No. 2 76
Carbonate of cobalt 6	Carbonate of cobalt ....
Red oxide of iron 3	Sulphate of iron 12
Carbonate of zinc hydrate. 3	Carbonate of zinc hydrate. 12
100	100

In the above the red oxide of iron in Salvetat's formula is the residue from calcination at a red heat, of sulphate of protoxide of iron, after washing in boiling water. In Bunel's formula, the sulphate of iron and the carbonate of zinc are calcined together before mixing with the other ingredient.

The mixtures are triturated, then heated sufficiently to frit the mass. We get No. 13 P. f. by increasing the proportions of flux. In the first formula it may be increased to 95 and in the second to 85.

This gray is very suitable for shadows in flesh tints; it mixes with all the colors and glazes well.

NO. 14. SOFT GRAY.

Gray No. 12.........20 or 33	Flux No. 1............... 50
Blue No. 28 T........25 or 27	Blue No. 28 T............ 10
Yellow No. 41 B......25 or 27	Yellow No. 41 B.......... 10
Carb. zinc hydrate...30 or 13	Carb. zinc hydrate 30

<div align="center">

100   100   100

</div>

This is a rather complicated gray and may easily be spoiled if but one of the colors of which it is formed varies in its composition. It was formerly known under the name of gray No. 4. It is extremely fusible and should be used carefully for it will very easily destroy the color with which it is associated. It is used on account of its fusibility to flux those colors which can only be laid on in a very thin coat and would, in consequence, have no gloss.

According to Salvetat this color can also be made by taking:

Flux for gray No. 2 or 2S 92
Carbonate of cobalt 5
Yellow oxide of iron 3

It is melted at a low heat, or it will be sufficient to frit the mass, placing the mixture in a double clay crucible in order that the heat may be conducted more slowly.

NO. 15 BLUISH GRAY.

Gray No. 12 50
Blue No. 28 T................................... 50

<div align="center">

100

</div>

This gray is used the same as No. 12, but it is reserved more especially for the bluish tints in carnations.

All the above grays have been tried on English tender porcelain and on fine faience, the tender porcelain was from the manufactory Creil (France) and the fine faience from the Johnston works at Bordeaux (France) and also from Creil and Montereau. These colors worked perfectly in the retouching firing at Sevres, but in the first firing they deteriorated somewhat and threatened to scale off. On firing the second time it was necessary to remedy these faults by replacing flux

No. 2 by one of the two fluxes No. 2 A or No. 2 B. Both of them Salvetat's formulas.

	No. 2 A.	No. 2 B.
Minium	71	73
Etampes sand	23	24
Calcined borax	6	3
	100	100

These materials are melted together and similar precautions are taken as in the case of flux No. 2.

PLATINUM GRAY.

To the above receipts, which furnish grays, we should add metallic platinum. For thirty years I called the attention of chemists to the use of this body, which by its infusibility, its unchangeableness under the influence of most chemical agents, even at the high temperature of the sharp fire, ought to have recommended it.

When we mix one part of platinum powder with three parts of a flux composed of 3 of minium, 1 of sand and ½ of calcined borax, we get a gray of a very fine tint, with the best qualities for painting on porcelain and of which it is easy to understand its superiority over all other grays employed up to the present time.

Whenever oxides of iron and of cobalt, or of cobalt, of iron, of manganese or of copper, are present together in any noticeable quantity, together with the siliceous matter capable of melting at the temperature to which we expose it, the color resulting from the fusion of this multiple composition is black, whether the oxide of cobalt is in the blue state or not, whether the iron is red or brown in the original mixture. This proposition is true even for the high temperatures of the crystal furnaces as well as for the still higher glass furnaces.

Upon these reactions, known to all chemists, are based the preparation of the grays and blacks generally used for painting hard and tender porcelain, crystal, glass, etc. We modify the shade and the intensity by varying the respective proportions of the oxides of cobalt, of iron, of zinc and by increasing the proportion of flux, called flux for gray, in order to thin the color for obtaining grays that are more and more clear.

Now the blues are made with oxides of cobalt and of zinc and these colors are the brighter, the less these oxides contain of oxide of iron.

Reds are furnished by oxide of iron, ochres by oxides of iron and zinc, and these tints are the purer in proportion, as the oxides of iron and of zinc are themselves free from foreign oxides, such as copper and manganese.

It is, therefore, evident that when an artist wishes to lower a blue, a red or an ochre, and that he mixes with it one of the grays or blacks that our existing palette places at his disposal, he makes a mixture, the proportions of which he does not know, of oxides of iron, of cobalt and of zinc, the color of which is black, and of which he cannot forsee the intensity nor shade, no matter how great his ability may be. Besides this, as the tint after the firing is not at all the same as when applied in painting, because the bluish and the red tints are changed and may disappear entirely, he cannot give to his un-burned painting the appearance it will have after the gloss is developed by firing. It is necessary for the painter to be guided by his judgment and for him to harmonize his work, seeing it, not as it is in reality, but as it will be after it is developed by burning.

This is an inconvenience, and a very serious one, above all in figure painting and in the reproduction upon porcelain of the works of the masters in oil painting, where it is im-portant to reach perfection.

A very simple experiment puts in evidence the results I speak of; if a plate of hard white porcelain has a band of blue painted across it and burned in; then crossing this, at right angles, another band, but of red, is painted and also burned in, after this firing it will be found that where the bands are separated they are respectively red and blue, but where the two bands cross each other it is gray, and may even go so far as black in its intensity, it partakes of neither a red nor a blue tint. The result is the same, no matter which is the tint first applied. The tint varies according to the thickness of the bands of color and the temperature at which they have been fired.

Platinum does not cause any of these inconveniences; as it does not contain any oxide of cobalt, it is well adapted for lowering reds and ochres without there being any danger of the firing making them too dark. As it does not contain any

oxide of iron there is no fear that in mixing it with blues it will blacken them or darken them more than is desired; it gives to the mixture exactly the desired shade and keeps this after, the same as before firing.

Considered in regard to its manufacture it is a very easy color to reproduce, it is always the same, both in color and intensity. The platinum powder is easily prepared; all we have to do is to precipitate it from a solution of chloride of platinum by an ammoniacal salt in excess and heat it until this latter salt is completely driven off; we thus obtain the platinum in the form of a gray powder; this can be at once mixed with the flux in the proportions above given and it is easily ground up.

Platinum is not the only metal which, employed in this way, supplies a useful color. All the metals that are ordinarily found associated with it, reduced in a similar manner, will serve and with equal superiority over the grays composed of cobalt and iron.

I have, to this end, tried palladium and ruthenium. Palladium gives a paler gray; ruthenium a gray which is redder than that from platinum.

BLACKS.

Blacks are obtained with the aid of the same materials as grays, by using rather less flux. The same as for grays, flux No. 2 is used, which being more fusible permits of the introduction of a stronger proportion of oxides to the color.

The blacks used at Sevres for decorating hard porcelain are:

No. 17 grayish black, No. 18 brownish black, No. 19 deep black, No. 19 P. f. deep black for grounds, No. 20 iridium black.

NO. 17 GRAYISH BLACK (SALVETAT.)

Flux for gray No. 2S	85
Carbonate of cobalt	10
Ammoniacal oxide of iron	5
	100

These are fritted in a crucible until the required tint is obtained. Too much heat will give a black that is too deep. By ammoniacal oxide of iron is meant the oxide of iron hydrate precipitated by ammonia from a dilute solution of nitrate, or of chloride of peroxide of iron.

This color has a blackish tone, which we might dispense with in our palette, but it is useful to have because of the difficulty in shading off blacks into grays with the brush.

NO. 18 BROWNISH BLACK (BUNEL.)

Flux for gray No. 2 or 2S	76
Carbonate of cobalt	16
Ammoniacal oxide of iron	8
	100

These are fritted together to the desired tint. A more certain way of getting brownish black is to take instead of 8 parts of ammoniacal oxide of iron, 4 parts and 4 of red oxide. This brownish black enables the artist to obtain brown black tones, which it would be difficult for him to produce by mixing, on his palette, red with black.

NO. 19 DEEP BLACK AND NO. 19 P. F. DEEP BLACK FOR GROUNDS.

Salvetat.		Bunel.
Flux for gray No. 2S...... 78	Flux No. 2............... 55	
Carbonate of cobalt 11	Oxide of copper 9	
Ammon. oxide of iron.... 11	Calcined oxide cobalt 9	
——	Oxide of manganese 9	
100	Blue No. 28 T.. 18	
	100	

In each receipt the materials are melted together.

For the black No. 19 P. f. more of No. 2 flux for gray is used. This color should mix, without exception with all the other colors, even with the reds, in which it always dominates; it is this quality which makes Nos. 17 and 18 indispensable.

NO. 20 IRIDIUM BLACK (MALAGUTI.)

Flux for gray No. 2.................................	75
Sesquioxide of iridium	25
	100

The materials are triturated together and employed without further preparation.

This is a very good color and possesses all the qualities that we can wish for in blacks and which black No. 19 rarely presents, that of mixing with all colors and above all with reds, keeping intact after firing, the shade of color at which it was mixed; but iridium black is expensive and that fact explains the preference which has generally been shown for blacks obtained with iron and cobalt.

All these colors are suitable for tender porcelain, faiences, etc., provided they are burned in at the temperature of retouching fire.

To employ them in the first fire for painting we must make an alteration in the fusibility by using flux No. 2A or 2B. As this remark applies to all the colors composing the Sevres palette we shall not need to repeat it.

For blacks for French tender porcelain we find in the old formulas of the Sevres works:

```
1st, T. A. Oxide of manganese ..................... 19
           Saltpetre .......... ..................... 59
           Etampes sand ......... ................. 19
           Calcined borax ......................... 3
                                                   ___
                                                   100
```

These materials were crushed, melted together, then pulverized. There was then taken:

```
Of the above melting ........................... 15
Peroxide of copper .............................. 5
Commercial black enamel ....................... 80
                                                ___
                                                100
```

This mixture was crushed and burned on an iron plate under a muffle.

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2nd, T. B. Oxide of manganese ..................... 12
           Carbonate of cobalt .................... 6
           Black enamel ......................... 49
           Minium ............ ................. 12
           Saltpetre .......... ............... .. 12
           Blue Ashes ........................... 9
                                                 ___
                                                 100
```

This was melted; thereupon was taken:

Of the above melting 89
Blue ashes 11
                                                 ———
                                                 100

fritted together and a fine black was obtained.

3rd, T. C. Oxide of manganese 12
Peroxide of copper 50
Black enamel 38
                                          ———
                                          100

crushed together and fritted under a muffle.
A fusible black for painting was obtained by taking:

Calcined blue ashes................... 25
Rocaille flux No. 1 75
Sea salt (a pinch) ....
                                                  ———
                                                  100

This was roasted in a muffle, but taken out as soon as it
swelled, in the fear that it would become gray.
For blacks for grounds T. D. they used:

Minium 11
Black melt 89
                                                   ———
                                                   100

This black melt was composed as follows:

Oxide of manganese 12
Blue ashes 6
Black enamel 82
                                                 ———
                                                 100

Common pottery rarely exhibits this color, but we see it in a
high degree of perfection on Græco-Italian production.

BLUES.

Blues are obtained from cobalt, brought to the condition of
a silicate or borate of oxide of cobalt. It is only in this state

that we can produce a blue with this metal, or by causing it to combine with alumina and phosphoric acid; but this latter coloring is destroyed by the influence of alkalies and by conditions which, up to the present, we have not been able to determine, in order to learn how to avoid them. On the other hand, the preparation of silicate of cobalt is quite easy. It is a good solid color and resists high temperatures.

Silicate of cobalt has been used for a very long time on the most varied descriptions of pottery. We find it applied on European pottery, and throughout the world on fine and common faience, stoneware and finally on bricks of the antiquity of which there can be no doubt. This is readily explained by the ease with which this vitrifiable color can be prepared.

Cobalt is not the only material which will produce blue, or at least bluish vitrifiable colors. Copper makes a turquoise blue, which is highly esteemed at the present time. The tender porcelain of Sevres obtained its varied tints from copper, and it is to this that the Egyptian pottery owes its greenish blue color.

The blues used at Sevres for painting on hard porcelain are:

> No. 22, Deep blue or indigo.
> No. 23 A, Turquoise blue.
> No. 23 A. P. f. Turquoise blue for grounds.
> No. 24, Azure blue.
> No. 24 P. f. Azure blue for grounds.
> No. 25, Ultramarine blue.
> No. 28, Sky blue.
> No. 28 T, Tender sky blue.
> No. 28 P. f. Sky blue for grounds.

NO. 22 DEEP BLUE OR INDIGO.

Flux for gray No. 2 61
Carbonate of cobalt 13
Carbonate of zinc hydrate 26

<div align="right">

100

</div>

All the authors agree upon the above proportions as producing a very fine blue.

This color of whatever tint, when used in painting, should be capable of being turned to gray and to black by the admixture of these colors. Carmines are destroyed by it, but violets and gold purples mix with it very well. Reds spoil it completely, therefore we only mix the two by superposition. It is necessary to place the red above the blue to get a tint which combines these colors.

NO. 23A TURQUOISE BLUE AND 23 P.F. TURQUOISE BLUE FOR GROUNDS.

This color, as it is at present prepared, does not exhibit all the qualities that we have a right to expect, even when made by the best manufacturers. Messrs. Delfosses make it of a fine tint, which glazes well, but the color has no body. Morteleque has made a turquoise blue with more body, but it is wanting in life and brilliancy.

Louis Robert appears to have got the nearest to the solution of these two conditions, body and beauty of tint. The following is the receipt for that which he prepared for the Sevres works:

Alum	92
Carbonate of cobalt	6
Carbonate of zinc	2
	100

The carbonates of cobalt and zinc are dissolved in hydrochloric acid. These solutions are mixed with the aqueous solutions of alum, then it is filtered and precipitated to neutralization, with carbonate of soda; the precipitate is washed in running water, gathered on a filter, dried and finally pulverized very finely.

This pulverized precipitate must then be calcined in a sharp fire, stirring the material in order that it should be calcined uniformly. At a cherry red heat the blue color develops. If calcined at a higher temperature the torquise blue tint becomes violet and is destroyed; it is therefore necessary to watch the operation of calcining very carefully and stop it when the soft blue tint is reached.

The blue being secured we mix the color with two and a half times its weight of flux; but without melting it, they are intimately mixed by grinding together.

The flux is composed of:

Minium	60
Boracic acid (pure).......	20
Etampes sand	20
	100

These materials must be well mixed in a mortar, then melted and poured out as soon as the sand is dissolved; pound the melt; sift the powder and mix it with the oxide in the proportions indicated.

As has been remarked, it is indispensable for the preservation of a turquoise blue tint, that the flux should be as neutral as possible. The presence of powerful bases, such as soda or potash, should be altogether avoided.

This color serves for painting like No. 22 and should possess similar qualities.

For blue 24 P. f. a little more flux is added.

NO. 24 AZURE BLUE AND NO. 24 P. F. FOR GROUNDS.

Flux for grays No. 2	67
Carbonate of cobalt	11
Carbonate of zinc	22
	100

These are triturated and melted, the same as for indigo blue, the above proportions have been adopted by all the chemists who have occupied themselves with this matter.

NO. 25 ULTRAMARINE BLUE.

The preparation of this color appears to be subject to certain conditions which we have not yet succeeded in discovering. In some samples which we analyzed we found cobalt, alumina, oxide of zinc and a little arsenic; in others we have found the same elements, but combined with phosphoric acid. From these indications we have made a number of attempts to produce this color by preparing it from cobalt blue, by the calcination of a mixture of hydrate of alumina and hydrate of phosphate of cobalt, with the same proportions we have always obtained, at one time a blue which was not affected by the flux, at another on the contrary, one that was destroyed entirely and became black.

This blue, of which the tint differs considerably from the

preceding blues does not mix so well. Nevertheless painters often use it for those blue portions which are in full light, blending it with blues No. 22 or 24 and carried over into the shadows by gray or black; or else place it as a local color, which is shaded by superposition of gray, black, etc.

NOS. 28 SKY BLUE; 28 T. TENDER SKY BLUE AND 28 T. P. F. BLUE FOR GROUNDS.

Flux for gray No. 2	79
Carbonate of cobalt	7
Carbonate of zinc	14
	100

Crushed together and melted.

For a tender sky blue 95 parts of flux are used and 90 parts for the sky blue for grounds.

This color, which is generally used for skies, distances, etc., has besides a special use; when a painting, in consequence of some parts becoming dull in the retouching fire, has to be fired a third time, the painter is compelled to retouch his entire work; if he neglects this precaution, all the rest of the picture will become dull. It is under such circumstances that, for retouching the blues of a painting, No. 28 is of great value.

In all the cobalt blues, which owe their color alone to the presence of silicate of cobalt, it is necessary that this salt should form and this condition necessitates the employment of a flux for gray, containing an excess of boracic acid. This flux (more fusible than rocaille flux, which, by itself, does not produce a fine blue), permits of the intensity of the coloration being augmented while retaining the fusible quality.

The cobalt blues made according to the preceding prescriptions; with the exception of the turquoise and the ultramarine blues; go well on tender porcelains and faience.

The processes used for the ancient Sevres porcelain, give various receipts for making fine deep blues for painting; we copy some of them which we have proved:

Etampes sand	39
Calcined carbonate of soda	39
Calcined borax	3
Calcined oxide of cobalt	19
	100

The whole is put into a clay crucible and heated in a good blast fire for about a hour; it is allowed to cool. When the mass is solidified in the bottom of the crucible this is broken and the chunk of blue glass is ground up.

A fine blue, called "royal deep blue" is made by taking

Carbonate of cobalt	29
Etampes sand or silica	29
Carbonate of potash	42
	100

The result of melting these materials together is a blue mass, almost black, but very fine; this glass is powdered and mixed with half its weight of rocaille flux and melted a second time: This is known under the name of blue No. 2.

To obtain a pale blue we take one part of blue No. 2 and 4 parts of rocaille flux.

For a blue for grounds take

Blue	50
Litharge or minium	50
	100

Melted together.

We have said that turquoise blue for hard porcelain will not do for tender porcelain. It is not to cobalt, but to copper that we owe this color. Formerly they made it at Sevres by taking minium 33 and aqua marina (stone) 67 crushed and melted together in a crucible. We have not been able to procure any samples of aqua marina that, with the addition of half its weight of minium, would give this rich color.

Common faience, as well as Persian faience, often shows a blue ground, which was probably fired at the same time as the glaze, though we have no certainty on this point. We think that contrary to the usual practice with porcelain, the blue enamel, reduced to powder, is applied directly by immersing the unbaked ware in it and not by applying it on the white glaze on ware already fired in white.

Antique Egyptian and Arabian pottery, already noticeable on account of the highly siliceous nature of its body, occupies a remarkable place in our estimation on account of the beauty and success of its turquoise blue and bluish green grounds.

The composition of these two colors very closely approaches that of turquoise blue for tender porcelain. The coloring principle is the oxide of copper but in the latter there is lead while in the antique ware an alkaline silicate alone forms the fusible principle.

For a long time it was not supposed that there was any copper in these Egyptian pieces, but we know now, thanks to the researches of Buisson, Laurent, Malaguti and Salvetat, that beyond a doubt, copper is the coloring principle, and oxide of cobalt does not play any part, for none of it has ever been found in these Egyptian blue glazes.

We do not pretend to deny that the Egyptians were acquainted with the properties of cobalt as a blue coloring principle, on the contrary they knew it very well, but they reserved it for the decoration of glass, in the manufacture of which they excelled as we may see by the glass enameled in white, yellow and bluish green, which they have left us.

We analyzed one of these pieces of glass and found it contained silica, alkalies, cobalt and a little lime in the glass; silica, lead and tin in the white enamel; silica, antimony, lead and soda, in the yellow enamel; finally, silica, copper and soda in the bluish enamel; completely confirming the results obtained twelve years previously by M. Laurent, whose ability as a chemist is so well known and proving that that industrious people had already made use of all the elements of which we make use today in the manufacture of enamels.

The Arabs appear to have followed the Egyptian methods, at least for pottery. We find in their work the same kind of body, the same kind of glaze and the same coloring.

We have not made any attempt to reproduce this color, but it may be useful to state that it could doubtless be done, without any serious difficulty, by melting together sand, soda and copper; while taking care that the proportions shall be suitable, so as not to have a flux which will be too deliquescent.

GREENS.

Green is obtained either from oxide of chromium or from peroxide of copper. The use of chrome oxide is comparatively modern, it was first employed at Sevres in the early part of this century. The use of copper, on the contrary, as a green coloring material, can be traced to the remotest antiquity,

as is proved by the samples of ancient Egyptian and Arabian pottery.

These two materials can be employed with advantage on every kind of body, particularly if the body is one that will not commence to melt at the temperature at which the green fires; nevertheless experience has demonstrated that copper greens are more beautiful and more reliable on glazes with an alkaline base than chrome greens, which always have a tendency towards yellow. The chromes are preferable on acid glazes, such as pegmatite and other boro-siliceous coverings.

The chrome greens used at the Sevres factory for painting ing and they require a special flux. The flux employed by M. Bunel and which recommends itself on account of its acid composition, is the flux for carmine No. 3.

The chrome greens used at the Sevres factory for painting and decorating hard porcelain, were:

> No. 34 Bluish green.
> No. 36. D. Deep green, hard.
> No. 39. Brown green.
> No. 35. P. f. Grass green for
>   grounds.
> No. 36. T. Deep green, tender.

NO. 34. BLUISH GREEN.

We take an intimate mixture produced by grinding in water on a glass slab, of the following:

	Salvetat.
Oxide of chrome	50
Carbonate of cobalt	25
Carbonate of zinc (hydrate)	25

When the mixture is dry it is calcined for about a quarter of an hour in a rather sharp blast fire. Of this calcine we take 25 parts and of flux No. 3 or No. 6, 75 parts and grind them together. They are not melted.

This color, like the two following, Nos. 35 and 36, are well defined green tones, entering into any part of a picture where their tints are required, they can be modified by addition of the yellows, Nos. 41 B. and 43, ochre, No. 50 AV, the browns, Nos. 68, 70 and 75 and all the other colors of the palette.

NOS. 35. GRASS GREEN AND 35 P. f. GRASS GREEN FOR
GROUNDS.

A pure oxide of chromium, by itself, will not give so bright a tint as the one under consideration, which is also known as Pau's green. This fine color is produced by mixtures of yellow green and blue, varying according to the tint required.

A sample prepared by Pau was analyzed by Malaguti, who, on examining it under the microscope, found there were four different powders.

The first was white, this was a borosilicate of lead and soda; the second a yellowish powder, contained antimony; the third, green, contained chrome oxide and some cobalt; the fourth blue, contained cobalt in the blue state and not vitreous.

The third and fourth are, perhaps, only mixtures of chrome oxide, cobalt oxide and of zinc oxide, which latter the analyst neglected to look for, but the presence of wnich appears to be indicated, by the loss, which is as much as 5 per cent.

Malaguti found, by his analysis the following, though he regards it as an approximation only:

Oxide of lead	45
Borax	10
Silica	16
Oxide of cobalt	3
Oxide of chrome	6
Oxide of antimony	15
Loss	5
	100

On adding together the color elements on the one hand and the fusible elements on the other, we shall find that their sums bear the ratio of 29 to 71, or 30 to 70, which is different to the ratio of 1 to 3 which we have remarked between the oxide and the flux necessary to give it a glaze and which, as the result of experience, has been generally adopted. We note here a fusibility resulting from the large number of oxides entering into the composition of the color, this we find to be in agreement with what we know about the fusibility of the silicates in general.

NO. 36. D.   DARK GREEN (HARD), AND NO. 36. T.   DARK GREEN (TENDER).

We prepare a chrome oxide (Dark green, V.), by rubbing up together with water, on a glass slab, the following mixture:

Oxide of chromium 75
Carbonate of cobalt 25

This is calcined in a good fire, the same way as the bluish green oxide; we thereupon mix together of the oxide (Dark green V.) 25 parts and flux No. 3 or 6, 75 parts. These are ground together on the slab without melting them. For the dark green 36. T. (tender) we use 80 parts of flux to 20 of dark green oxide.

NO. 39.   BROWN GREEN.

Brown green is obtained by mixing with the hard deep green, in suitable proportions, either yellow-brown No. 50 AV, nut-brown No. 70 or sepia brown No. 75.

This color is one that we can do without, though it is useful to have it, because of the difficulty of getting the exact tint desired by mixing dark green with browns on the palette, without forcing the brown; in this respect it is a color which is very useful to landscape artists for breaking up all their greens.

When we prepare chrome oxide it happens sometimes that we get a brown; we would naturally use this oxide for making the brown green No. 39.

We recommend that the flux for carmine be changed slightly so as to render it more suitable for greens. This flux is not very fusible and has a kind of opacity, which gives a whiteness to the chrome oxide and a tint that is not always pleasant. We consider the following flux as more suitable to chrome:

	Salvetat	Meissen
Boracic acid	18	9
Sand	9	18
Minium	73	73

The above fluxes are mixed with the bluish green, the deep green or the brown green oxides, always in the proportions of 1 of oxide to 3 of flux.

The greens which we have given, made from oxide of chromium, are good colors for tender porcelains and faience, provided always, that they do not have to be fired at a temperature capable of fusing the glaze of the ware. Under the latter condition it is better to use copper greens, and in such case the following are the formulas which we find in the collection of receipts at Sevres for colors on tender porcelain:

These greens, which are known as emerald green, dragon green and deep green, have all for their common base a ready made color, V, which is composed of equal parts of a yellow, P, which we will describe later, and a yellow green, V. J. for painting, which is made by melting together; opaque yellow green enamel 67 and minium 33.

The emerald green is made by melting together colors V. 92 parts and blue No. 22, 8 parts.

Dragon green is made of color V. 86 parts and blue No. 22, 14 parts, crushed and melted together.

Deep green is made according to one or the other of these two prescriptions; color V. 75 parts, blue No. 22, 25 parts; or color V. 50 parts and black T. A. (page 265) 50 parts. This is melted together and mixed with an equal weight of deep yellow for painting.

According to these old Sevres formulas, to get a fine and bright green we take aqua marine 27, opaque green in cake, 40 and minium 33 parts, these are triturated and melted together.

For a brown green we take blue No. 22, 33 parts, tender black 67 parts; crush and melt together, then of the preceding melt take 40 parts and deep yellow for painting 60 parts.

The greens prepared in this way are also good for English tender porcelain and for fine and common faience.

M. Kuehn, director of the royal porcelain works at Meissen, very generously gave me all the formulas for the beautiful chrome greens which distinguish the Meissen productions.

The preparation of the chrome, which becomes the base of all the shades of greens in which chrome enters as a colorant, is done at Meissen as follows:

Oxide of chromium and carbonate of cobalt hydrate, are calcined together in portions of about 120 grams weight, in porcelain crucibles. These are placed in a sharp fire kiln in

those parts where the temperature is low. On taking them
out of the fire the calcine is crushed and then washed with
boiling water. Three parts of the resulting powder is mixed
with one part of carbonate of magnesia, which is calcined
as before, in a sharp fire, but in the weakest part of it and
at a lower temperature than the preceding calcination. The
new calcine is crushed and again washed and becomes the
base of all the other green colors.

NO. 1. DARK GREEN.

Base 16.5
Lead flux 83.5

The flux is composed, 73 parts of minium, 18 of quartz and
9 of boracic acid.

NO. 2. LIGHT GREEN.

Base 12.5
Flux, as before 62.5
Yellow 25.0

The composition of the yellow is as follows:

Yellow oxide of iron, hydrate, precipitated from
    sulphate of iron 4.5
Calcined oxide of zinc   9
White oxide of antimony 14.5
Flux, as before 72

NO. 3. YELLOWISH GREEN.

Base 9.25
Flux 18.50
Yellow 72.25

The yellow used here is composed as follows:

White oxide of antimony 4.50
Calcined oxide of zinc 4.50
Quartz 18.25
Minium 72.75

No. 4. BLUISH GREEN.

Base 5.75
Calcined oxide of zinc 5.75
Tin oxide, by calcination 5.75
Flux, as before 16.75
Supplementary flux 66

This supplementary flux has the following composition:

Minium	34.5
Quartz	24
Seilitz kaolin	12
Calcined feldspar	12
Boracic acid	17.5

Chrome green for under glaze, is put on the biscuit, the same as the blue, but it is put on with water, consequently there is no necessity for passing it through the fire to burn off the oil, as has to be done with blues.

It is better to mix this color with a little glaze; it is laid on, either with a paper stencil, or else by printing from impressions taken from proofs on unsized paper, but which is covered with a thin surface of mucilage. The paper is removed by water. Whichever method is used, it is advisable that the overglaze be rather thick.

YELLOWS.

We get yellow by means of antimoniate of potash and oxide of lead. This is much the same thing as Naples yellow, made more or less deep by different additions of oxide of zinc, oxide of iron and, sometimes, of tin oxide. We can also obtain a deeper yellow by the addition of oxide of uranium.

Chromate of lead is sometimes employed for orange yellow, but this color does not mix well with others; it is, too, somewhat uncertain, which causes it to be used only for grounds. Oxide of uranium has a similar defect of being a bad mixer, it is, therefore, also, kept for grounds.

The yellows in use at the Sèvres works, for painting and decorating hard porcelain, are:

No. 41. A. Pale fixed yellow;
No. 41. B. Pale yellow for painting;
No. 42. P.f. Jonquil yellow for grounds;
No. 43. Deep yellow for browns and greens;
No. 45. Uranium orange yellow;
No. 46. Deep yellow;
No. 46. A. Fixed deep yellow;
No. 47. Pale yellow for reds;
No. 52. Chrome yellow orange.

No. 41, A. FIXED PALE YELLOW.

	Bunel
Yellow No. 41. B.	33
Commercial White enamel	67

The most suitable white enamel is that which is sold under
the trade mark of a Maltese cross. This enamel varies in
fusibility. It should be tested to ascertain the exact quantity
to be added to the yellow No. 41. B. They are mixed, melted
together and poured out, or they may be ground up together
without melting.

This color serves for clearing the yellow portions, which have
not been reserved in the sketch. It should possess all the
qualities of permanent white, that is to say, it should glaze
well, without being too fusible, it should not scale off, even
when laid on thickly; in addition to these qualities it must
have a good bright yellow color.

No. 41, B. LIGHT YELLOW FOR BROWNS AND GREENS.

	Salvétat	Bunel
Flux for gray No. 2 or 2s	81 or 72	70 or 75
Antimoniate of potash	12 or 16	14 or 17
Carbonate of zinc hydrate	6 or 8	7 or 8
Oxide of iron, by water	1 or 4	0 0

These materials are triturated together and melted at a
gentle heat but sufficient to insure complete fusion.

This yellow should mix well with all the other colors, but
particularly with browns and greens. It is this that gives the
clear yellows that painters need.

No. 42, P.f. JONQUIL YELLOW FOR GROUNDS.

	Bunel
Rocaille flux No. 1.	86
Calcine (1 tin 3 lead)	8
Calcined carbonate of soda	3
Antimoniate of potash	3

These are triturated and melted.
This color will not mix. Some artists, nevertheless, make

use of it for flower painting by employing it for local tints, which they glaze at once. for breaking up shadows.

The color can be improved by composing it as follows:

	Bunel	Salvétat
Flux for gray	81 or 72	79 or 75
Antimoniate of potash	12 or 16	14 or 17
Carbonate of zinc hydrate.....	6 or 8	7 or 8
Oxide of iron, by water.......	1 or 4	0 0

No. 43. DEEP YELLOW FOR BROWNS AND GREENS.

	Bunel	Salvétat
Flux for gray No. 2 or 2s...........	75.0	75
Antimoniate of potash	15.0	17
Carbonate of zinc hydrate	7.5	4
Red oxide of iron	2.5	4

These are triturated and melted.

We can obtain livelier colors by melting with oxide of iron, antimoniate of potash and oxide of zinc the elements of the flux, instead of the ready-made flux itself. We take:

	Salvétat.
Litharge, or minium	50
Etampes sand	17
Melted borax	8
Antimoniate of potash	17
Carbonate of zinc hydrate	4
Red oxide of iron	4

These are triturated and melted, but they must not be melted too much, or the color will have a greenish tint.

This color should, the same as No. 41. B, mix with all the other colors; it is from this that we get our deep yellows.

No. 46. DEEP YELLOW.

	Bunel	Salvétat
Flux for gray No. 2 or 2s..........	75.0	79 or 75
Antimoniate of potash	15.0	14 or 17
Carbonate of zinc hydrate	7.5	0 0
Red oxide of iron	2.5	7 or 8

These are triturated and melted together the same as yellow
No. 43. We may also use the following proportions, which give
a brighter deep yellow:

	Salvetat
Litharge, or minium	50
Etampes sand	17
Melted borax	8
Antimoniate of potash	17
Red oxide of iron	8

This is melted the same as No. 43. If overheated it becomes
greenish.

This color is deeper than No. 43 and can be used for the
same purposes, but it does not mix well, it should be employed
alone; we therefore require from it more freshness and vivacity
than from No. 43 and we reserve it for those portions that are
pure yellow. The parts in shadow are obtained by glazing over
the flat tint with gray or black.

No. 46. A. FIXED DEEP YELLOW.

This is the ordinary yellow No. 46, hardened by the addition
of a suitable quantity of white enamel of commerce.

This color serves to place in relief the high lights of deep
yellows, on those parts which have not been reserved.

No. 47. PALE YELLOW FOR FLESH TINTS.

Flux for gray No. 2 or 2s	84
Antimoniate of potash	4
Carbonate of zinc hydrate	4
Yellow oxide of iron	8

These are triturated and melted in a moderate fire.

This color has the property, when mixed with other colors
and above all with the reds, of attenuating their strength and
of glazing them in the thin parts; it is one of the most import-
ant colors for the figure painter, enabling him to model and to
blend, one into another, all the shades of the carnations.

When a painting is dull in some places and has to be re-
touched, necessitating refiring, it is with yellow No. 47 that we
reglaze, very lightly, those portions of the picture which, by

refiring, would become dull and matt. Used in this way it is a great assistance to the artist.

No. 45. URANIUM ORANGE YELLOW.

Orange yellow from uranium is only employed for grounds, though some artists use it for painting, laying it on in isolated touches and modifying the tint by glazing other colors over it. It is made by taking:

Flux No. 1 or No. 2............................. 75
Oxide of Uranium, pure........................ 25

This color may be melted or not, but if we wish to use it for painting, fusion at a gentle heat is necessary, to give it the warm tone which it takes after firing.

No. 52. CHROME ORANGE YELLOW.

This is procured from chromate of lead; we melt in a good fire, in a clay crucible:

Minium 75
Chromate of lead 25

A little sand may be added, but it must be very little. The silica yellows this color and facilitates its change under the influence of heat. It is preferable to add a little of the flux for gray to the product of the fusion, before using it.

This color, which is very unreliable, has, up to the present, only been used for grounds and for some ornaments; it does not mix, but when it is well made and properly fired; it gives a ground of a red orange cardinal tint, which is very fine.

All these yellows are good colors for tender porcelains and faiences. They can be rendered less liable to scaling, can consequently be laid on thicker, by replacing the flux No. 2 by No. 2 A, or No. 2 B., the composition of which we have already given.

It may be useful to add here the receipts employed at the Sévres works for painting tender porcelain.

Light yellows were obtained by melting together:

Pale yellow enamel .... 25 or 60
Rocaille flux .... 75 or 0
Minium .... 0 or 40

Or, instead of this:

```
Litharge or minium ........................... 65
Etampes sand ............ ..................... 21
Tin calcine .......... ...................... 8
Calcined carbonate of soda ................... 3
Antimoniate of potash ....................... 3
```

Instead of the tin calcine we can take an equal quantity of white enamel.

For the deep yellows we melt together:

```
Rocaille flux No. 1...................... 50 or 64
Naples yellow .............. ............ 45 or 32
Red oxide of iron ...................... 5 or 4
```

The first yellow mixes well with the reds.

The yellow P., which enters into the composition of the greens, is prepared as follows:

```
Brown oxide of iron .......................... 23
Deep yellow, ready for painting ................ 33
Minium ............... ..................... 34
```

The whole melted together to a lump. This lump is triturated and one part of it to four parts of yellow, ready for painting, melted together, constitutes the yellow P.

BROWN YELLOWS.

The brown yellows are obtained by mixing and crushing together varying proportions of oxide of zinc and oxide of iron prepared by precipitation, either from the muriate of peroxide of iron by ammonia or from the sulphate of protoxide of iron by water.

It should be noted that the tint varies, according to the oxide of iron and the nature of the oxide of zinc which we use. The oxide of iron hydrate in the brown yellow is destroyed and the color after firing contains only a zincate of iron, rendered adherent and glazed by the flux.

These colors are exceedingly delicate, they are consequently difficult to make, or at least to get them beautiful and good. The flux which suits them is the flux for gray; it gives them a fine glaze and does not hurt the mixtures with reds, browns, blacks or grays, which only take their glaze from this flux.

The browns in use at the Sèvres works for painting and decorating hard porcelain are:

No. 40. Pale yellow ochre;
No. 50. Yellow ochre;
No. 50. A. Deep yellow ochre;
No. 50. AV. Yellow ochre for greens;
No. 50. B. Very deep yellow ochre.

Among these brown yellows the Nos. 49, 50 and 50 A. are the colors of definite tint, which are used in painting and decorating as they are, without any change. We could get the same tints by mixing, but as they are so delicate and we should have to trust to our judgment in mixing the tints, it is preferable to make them up in definite shades, ready for use.

NO. 49. PALE YELLOW OCHRE.

Flux for gray No. 2........................... 80.2
Carbonate of zinc hydrate 15.0
Yellow oxide of iron 6.6

These are mixed, but not melted.

This color, like the succeeding Nos. 50 and 50 A, should mix with all the others, except that they do not mix perfectly with the greens, for which we use 50 AV.

NO. 50. YELLOW OCHRE.

Flux for yellow gray No. 2................... 77.0
Carbonate of zinc hydrate 12.5
Yellow oxide of iron 8.0

These are mixed without melting.

NO. 50, A. DEEP YELLOW OCHRE.

Flux for gray No. 2........................... 75.0
Carbonate of zinc hydrate 12.5
Yellow oxide of iron 12.5

Mixed without melting.

NO. 50, AV. YELLOW OCHRE FOR GREENS.

Flux for gray No. 2	71 4
Carbonate of zinc hydrate	14.3
Yellow oxide of iron	14.3

This is not melted.

The especial object of this color is to be mixed with greens to obtain warm tints; it is difficult to have it so that it will not darken the chrome greens with which it is mixed; its good qualities depend upon the qualities of the carbonate of zinc.

NO. 50, B. VERY DEEP YELLOW OCHRE.

Flux for gray No. 2	66.6
Carbonate of zinc hydrate	10.0
Yellow oxide of iron	23.4

This is not melted.

This color forms an easy transition from yellow ochre to red. It is used in painting for its own color and should permit of being modified by all the other colors, such as No. 49, 50 and 50 A.

These yellows are also good colors for tender porcelain and faience. They can be improved by replacing the flux for gray No. 2 by one of the two fluxes, No. 2 or No. 2 A.

REDS.

All the reds are got from iron. The oxide of iron can, according to the manner of its preparation, furnish a very great variety of tints, but which will not stand a very high temperature. All the tints produced by iron change in a sharp fire and the employment of this oxide is at present confined to the preparation of hard and tender muffle colors.

The Sèvres works possess, for painting on hard porcelain, all the following shades, got from pure oxide of iron and calcined at varying temperatures. This is extracted from the sulphate of protoxide of iron.

The well known colors of Mr. Pannetier, particularly the reds from oxide of iron, attracted my attention and I sought by

analysis, to determine their composition: the result of these researches was that the orange red was rendered more stable and brighter by the addition, to the oxide of iron, of oxide or zinc, or of alumina, and that the violets derived from iron owe their intensity and their bluish shade to the introduction of a very small quantity of oxide of manganese.

These iron colors of Pannetier's were above all remarkable for their perfect fusion. The analysis showed that the quantities of lead and of sand remaining the same as in the formulas given below, a portion of the oxide of iron is replaced by its weight of borax; the influence of this substitution upon the fluxing properties of the color will be readily understood.

The difference which exists between the two series of colors may be translated in a still more simple manner. In Pannetier's colors the flux consists of sand 1, borax ¾ and orange lead 3, which is a more fusible composition than that in which, for one of coloring oxide, we have only three of flux.

I have sought for the reason why two reds differed in brightness while they were alike chemically pure. I think the explanation which I propose will be accepted. It is as follows:

The difference in the shade which a pure oxide of iron acquires depends upon the temperature to which we bring it. All the shades are not maintained at the same degree; the higher the temperature the more vigorous the tone; we know that the different colors which oxide of iron takes vary from orange to violet, that is to say, they can be resolved into yellow, red and blue, simple colors which give a more or less deep gray, according to the intensity of the three elementary colors. The lower the temperature the more yellow is the color; the higher the temperature the more blue we get.

It seems evident to me that the color will be the purer the more it consists of molecules, which are identical in the modifications that they have received at any one temperature. The tint will therefore be absolutely pure if all the molecules have received the temperature ncessary to develop it, if none of them have been subjected to the action of a fire capable of modifying them, a fire that is either too weak, which left them yellow, or too violent, augmenting the proportion of blue.

The skill therefore lies in composing a color which consists only of such particles of oxide as have been subject to the same temperature. We can accomplish this result by operating upon small quantities at a time and by constantly stirring the mass.

We stop the fire when the temperature has been maintained for a sufficient time. The result of each preparation is tested separately and only those are added to each other which are seen to be identical in tint. For these tests it is of prime necessity that the sight should be thoroughly practiced and very keen. For this work considerable artistic study becomes the indispensable complement of the science of the chemist; for this reason M. Pannetier, who was himself for a long time occupied as a painter, has succeeded in bringing his production of colors to such a state of perfection.

I have no doubt that some day we shall make use of a rotatory apparatus for preparing the various tints of oxide of iron, similar to sulphurizing green ultramarine for the purpose of transforming it into blue.

The Sèvres reds are:

No. 55. Orange red;
No. 58. Blood red;
No. 62. Flesh red;
No. 62 T. Flesh red, tender.
No. 63. Carmine red;
No. 64. Lake red;
No. 66. Violet red;
No. 66A, 66 B. Deep violet red.

There is not the least difficulty in the preparation of these colors when once we have secured the oxide of iron of the desired tint. It is the preparation of this oxide which we find impossible to control just as we wish and to which we have to give our attention.

To make the color we take:

Red oxide of iron 25
Flux for gray No. 2 or 2 S..................... 75

For the tender colors, like No. 62 T., we increase the proportion of flux, which is made 77.8 for 22.2 of oxide of iron. We do the same thing when we want colors for grounds. As to the tender colors, when we use these it is indispensable that they should be laid on very thinly. The colors which are heavily loaded with flux, alter in firing, if they are laid on thickly, the oxide of iron disappears. The thin layers are always brilliant, for they are very fusible.

The mixture of oxide and flux is triturated in a mortar, then ground on a glass. The mixture is not melted.

All these colors having definite tints are very useful and their value depends upon their reliability in mixtures. The blacks, grays and blues do not mix well with them; they disappear entirely when we glaze them with yellows, upon which they can be laid well enough; we have seen that to reduce them and at same time to brighten them in the thin shadows, yellow No. 47 was composed.

The reds for tender porcelain and faience are made in the same manner; we can replace flux No. 2 by flux No. 1 for tender porcelain and No. 2 A, or 2 B for faiences, but this is not necessary if we only burn the colors on at the temperature of the retouching fire used at Sèvres.

The Sèvres recipes give a process for obtaining a red oxide, which I have not tested, but which it may, perhaps, be as well to publish; an intimate mixture is taken of:

Iron filings 25
Metallic antimony 25
Nitrate of potash 50

This mixture is thrown, by small portions at a time, for the antimony and potash are explosive, into a clay crucible, which is brought to a red heat. The mass resulting from this operation is washed with boiling water and the residue is mixed with its flux, in the same proportion as for pure oxide of iron.

Common pottery is sometimes decorated in red and we find examples of this in Roman and Campanian pottery, but this is a silico-alkaline gloss which simply increases the brightness of the color of the red slip upon which it is applied.

We may in this place, recall the touches of red which are seen in Italo-Greek vases, applied upon their fine black glaze. Although these materials form no part of vitrifiable colors, properly so-called, they may be considered here, inasmuch as they adhere to the ware by the action of a temperature sufficiently elevated to melt the black glaze upon which they are applied and prevent them being detached.

These red retouches, whatever shade they may have been, are due to ferruginous ochres. We have verified this presumption, both by analysis and by synthesis; the analyses revealed nothing in these, but iron, alumina and a little silica.

PURPLES, CARMINES AND VIOLETS.

These are the colors that are obtained from gold and are the three tints which only the purple of Cassius can give, when properly prepared and mixed with suitable fluxes. These are muffle colors, though they are not destroyed in a semi sharp fire, at least the purple and the violet are not changed much, but it is difficult to obtain a pure carmine at this temperature.

The gold colors used at Sèvres for the decoration of hard porcelain are:

No. 59 D. Carmine, hard;
No. 59. T. Carmine, tender;
No. 60. Purple;
No. 60. P. f. Purple for grounds;
No. 65. Violet;
No. 65. P. f. Violet for grounds.

NO. 59 D CARMINE, HARD, AND 59 T. CARMINE TENDER.

We take the purple precipitate of Cassius, in a moist state (prepared by one of the two methods given on page 154 of "Brick," for Dec., 1896). This is spread upon a glass and flux No. 3 is added to it; about three parts of flux to one of oxide; besides this we add a few grains of chloride of silver and grind all together until we have an intimate mixture and the flux is reduced to an extreme state of fineness; for the tender carmine, No. 59 T., we add a little extra flux. As the precipitate of Cassius must be employed in a wet state we have to guess at the proportions, but practice soon enables us to produce, with certainty, a good color, which fluxes well. When the chloride of silver, the purple oxide and the flux are well mixed, we test the color; if it proves to be dull, we add more flux; if it is of a dirty yellow color, there is too much chloride of silver in it and more purple oxide and flux must be added.

The better way to introduce the chloride of silver into the color is to melt it, or rather to frit it at a light heat, with the flux for carmine, after grinding the two together in water.

The flux for carmine used in England has a very different composition to that which we gave as employed at Sèvres. Mr. Malaguti subjected a fine specimen of English carmine to analysis and found it composed of:

```
Silica  ....................................... 36.13
Borax  .......................................24.49
Oxide of lead...................................26.66
Oxide of tin...................................10.70
Gold  ........................................ 2.02
```

On joining the silica, the borax and the lead, as forming the flux, and the oxide of tin and gold as forming the gold oxide, we find that the proportion by weight of the gold oxide to the flux is as 1 to 7.20. It follows therefore that the borax, the lead and the silica are in the proportions of 2.20:2:3, which indicates for the composition of the flux:

```
Sand  ...................................41.68
Borax  ...................................27.77
Oxide of lead...................................30.55
```

The Sèvres flux contains:

```
Sand  .......................................33.33
Borax  .......................................55.56
Oxide of lead...................................11.11
```

On adding 1 of gold oxide to 7.20 of flux, we have a composition for carmine, which, stated in hundredths, is:

```
Silica  .......................................36.59
Borax  .......................................24.39
Oxide of lead...................................26.82
Gold oxide...................................12.20
```

Figures which agree closely enough with our experience. The traces of silver, which doubtless were present, must have escaped Mr. Malaguti's notice. In fact, we do not know a single example of carmine without a trace of silver in it.

Carmine is used, principally, in painting flowers; for roses the greatest freshness and clearness are required. It is shaded by mixtures of bluish grays, iron violets, or of bluish green. It is with difficulty mixed with blues, but is subdued easily enough with the browns, Nos. 68, 70 and 75.

NO. 60 PURPLE AND 60 P. F. PURPLE FOR GROUNDS.

Purple is made with carmine as a starting point, to this a little of the wet oxide of gold is added; this is ground up in water and tested in the same way that we do the carmine. A little flux is added for purple No. 60 P. f., which should be rather more fusible, in order to give a more highly glazed

ground. This color should approach carmine No. **59 D**, and should contain rather less of silver oxide.

Notwithstanding all the trials and the changes we make, it is clear that by this means we can obtain nothing more than a carmine deeper than carmine No. 59 D. This consideration determined some attempts to modify somewhat the flux for carmine so as to obtain a flux for purple, with the result that we discovered the flux, the composition of which we have given under the title No. 4 S.

When this flux is used we add to the purple precipitate of Cassius, a quantity of flux, equal to about one and a half times the oxide of gold; this is ground together with a few grains of chloride of silver, the same as for carmine No. 59 D.

This color, as also the next one, is better than No. 59 for mixing with blues Nos. 22 and 24. It also mixes well with yellow browns Nos. 50 AV and 50 B, and the browns Nos. 68, 70 and 75.

NO. 65 VIOLET AND 65 P. F. VIOLET FOR GROUNDS.

The gold violet, like the two preceding colors, is only made by empirical tests. We take a quantity of purple of Cassius, in the wet state, and an equal quantity of flux No. 1; without adding any chloride of silver. They are ground together on a glass, and the color thus made is tried. Some recipes indicate that a little cobalt blue should be added. This is a direction which should be carefully avoided. The purple of Cassius alone will give a very fine violet, but there must not be any silver in it, and it must have a suitable flux. It occurred to us that this color could be improved by modifying the rocaille flux; that it might be well to increase the proportion of minium, and on trying this the superiority of the flux given under No. 5 was demonstrated. It must not be forgotten that the oxide of lead, when present in too large a quantity, turns carmines and purples to violet.

When we fire onto tender porcelain, or fine, or common faience, carmines or purples that are prepared for hard porcelain, we find that the colors take on a tint like dregs of wine, or a violet tone. The small quantity of lead which the flux for carmine or purple contains, is increased by that which is in the glaze of a tender porcelain or faience, and which, when it melts, communicates itself to the colors. Among the recipes

used at Sèvres for purples for tender porcelains, we have found the following for a composition of flux for purple:

English flint glass...............................75
Calcined carbonate of soda.......................25

A flux, which is known as "Saxon," without lead, is probably used for the same purpose. It consists of:

Soda ash 30
Calcined carbonate of soda.......................30
Sand, washed and dried...........................40

The first of these two fluxes is triturated and melted. The second is melted in a sharp fire for two hours; it is then crushed and to four parts of it one part of calcined soda is added.

The whole is then remelted, the heat being kept up for two hours.

These fluxes, or the fluxes which we first gave, when the quantity of oxide of lead is reduced, should be suitable for decorating faiences.

The violets composed for hard porcelain can be applied equally well upon tender porcelain and faience.

We can, however, produce upon these wares violets of fine tints without the aid of purple of Cassius. Manganese will furnish these.

Following the Sèvres recipes we melt together, in crucible over good fire:

Nitrate of potash................................60.0
Etampes sand.....................................22.5
Manganese oxide..................................15.0
Melted borax......................................2.5

This is poured out, and of this melt we take 33.3 and of flux No. 1, 66.7.

Finally we take:

Of the preceding melt....................26.4 or 22.2
Etampes sand ....13 7 " 22.2
Salt of tartar...........................13.7 "
Nitrate of potash........................ 6.6 " 22.2
Minium ....39.6 " 33.3

The whole is put into a crucible, melted and poured out.

There is no doubt that the work with the above formula might be considerably simplified by making one melting only, which would do just as well.

To get a harder color we take:

Melt No. 2...................................26.7
Etampes sand..................................26.7
Carbonate of potash...........................13.3
Nitrate of potash............................. 6.5
Minium 26.7

The color used with this is put on in two coats.

BROWN-REDS AND BROWNS.

The brown-reds are obtained by means of oxide of iron, oxide of cobalt or manganese, oxide of zinc, fritted with the flux at exactly the right temperature to give it the wished-for depth of tint. These colors are durable enough and mix well; they are very valuable in artistic decoration. The flux which suits these colors is, in every case, flux No. 2; flux No. 1 is not fusible enough to give them a good glaze.

The browns used for painting and decorating hard porcelain at Sevres are:

No. 67. Red-brown;
No. 67. P. f. Red-brown for grounds;
No. 68. Reddish-brown;
No. 68. P. f. Reddish-brown for grounds;
No. 70. Brown for wood;
No. 75. Sepia-brown;
No. 75. P. f. Sepia-brown for grounds.

NO. 67 RED-BROWN AND 67 P. F. RED-BROWN FOR GROUNDS.

We can easily prepare this color with oxide of iron calcined to the point required to produce the color. Bunel's formula is: red-brown oxide of iron 25 and flux No. 2 B. 75 parts. Salvétat's is: brown oxide of iron 25 and flux No. 2 S. 75 parts. If the color is not quite brown enough we add a little of No. 70 or No. 75. It is ground on a glass without melting or fritting.

For No. 67 P. f. we slightly increase the proportion of flux.

This color, like Nos. 68, 70 and 75, is used in painting for its own special tint; it is also of great value for shading and for reducing all the other colors, with which it should mix in any proportion; it glazes well.

NO. 68 REDDISH-BROWN AND 68 P. F. REDDISH-BROWN FOR GROUNDS.

```
Flux No. 2 B. or No. 2 S.........................72.7
Carbonate of zinc, hydrate......................12.2
Red oxide of iron...............................12.1
Sepia-brown No. 75.............................. 3.0
```

This is ground, but not melted nor fritted. To make No. 68 P. f. we add a little more flux.

NO. 70 BROWN FOR WOOD.

```
Reddish-brown No. 78...........................50
Sepia-brown .......... .......... .............50
```

This is mixed and ground without melting or fritting. The color, applicable to any work, can also be made by taking:

```
Flux No. 2 S.....................................72.7
Carbonate of zinc, hydrate......................12.2
Oxide of iron, by ammonia.......................12.1
Carbonate of cobalt............................. 3.0
```

This is very lightly fritted, just enough to give it the required depth of tint.

NO. 75 SEPIA BROWN AND 75 P. F. WOOD BROWN FOR GROUNDS

```
Flux No. 2 B....................................70.6
Carbonate of zinc...............................11.8
Iron oxide, by ammonia..........................11.8
Carbonate of cobalt............................. 5.8
```

Or the above formula may be used with the substitution of flux No. 2 S. for flux No. 2 B. The mixture is triturated and fritted at a suitable temperature to give it the desired tint.

We can vary the tone of all these browns by replacing the ammoniacal oxide of iron by oxide of iron precipitated from sulphate in water and by substituting for the carbonate of cobalt a corresponding quantity of oxide of manganese.

All the above browns have been tried on tender porcelain and on faience; they do not change and they flux well. In the same way as with the grays, the blacks, the reds and the yellows, we can substitute for the flux for gray, either the flux No. 1 for tender porcelain, or the fluxes Nos. 2 A. and 2 B. for the faiences, if these have to be fired at a rather high temperature.

Common pottery is often colored brown, but this color is in the glaze and has about the following composition:

```
A fusible powdered brick (that of
   Paris or Sarcelles is generally
   Minium ........................52.......or......53
   Manganese ...................... 7......or....... 5
   used)....... ......... ..........41.......or......42
```

These materials are merely reduced to a powder and mixed with water, so as to form a thin soup-like liquid.

In some more recent attempts to produce colors for hard porcelain I modified, with advantage, the composition of the yellows (deep, medium and pale), making them in one melting. Made in the following manner there is no fear of scaling:

	No. 41 B.	No. 43.	No. 46.
Orange lead	840	840	840
Sand	240	240	240
Boracic acid	180	180	180
Antimoniate of potash	240	240	240
Flowers of zinc	60	30	...
Red oxide of iron melted		30	60

These are mixed and melted together.

OCHRES, BROWN, BLACKS AND GRAYS.

While preserving the distinction established between colors, properly so called and the enamels, I have made it clear that the colors should be considered as a mixture of coloring oxide and of flux. Starting from the principle that the oxide is the more refractory and, in consequence, preserves its color better if it has been heated at a higher temperature, I have adopted a general method of preparation, which is extremely simple and which I have found very advantageous. Besides this, instead of producing composite oxides by mixing certain proportions of pure oxides together, I cause the substances to react upon each other when mixed in weights determined by their chemical equivalents.

Taking, for example, the oxides for black, for bluish gray, the oxides for greens and the browns. To make the oxide for deep black I dissolve in hydrochloric acid:

```
      An equivalent of metallic iron............560 grams
      An equivalent of cobaltic oxide............400 grams
```

In this way we obtain the composition $Fe^2 O_3$ Co O; after complete dissolution this is filtered and precipitated with a solution of potash. The precipitate is washed and calcined. Three parts of flux are added to one part of the combined oxide.

The same oxide with more flux (nine of flux to one of oxide, for instance) gives the very fine bluish gray No. 15.

If we want to prepare a yellow ochre, or brown-yellow No. 50 A V. we dissolve as before:

Metallic iron 560, to get $Fe_2 O_3$

Metallic zinc 330, to get ZnO.

The hydrochloric acid disengages hydrogen; the oxygen of the water combines with the metal and the oxide thus formed, precipitated and calcined, represents $Fe_2 O_3$ ZnO. One part of this oxide to three of flux gives us the color of 50 AV.

For ochres and pale brown yellows, we add more flux.

For the browns, cold or warm, we add to the composite, $Fe_2 O_3$ ZnO, one-half, one-quarter or one-eighth, at pleasure, of equivalents of oxides of cobalt or of nickel. The browns in which nickel enters are warmer than those to which we add cobalt.

This method may be used also for the preparation of compositions where alumina, chrome oxide, oxide of iron, oxide of zinc are united; they are dissolved, precipitated with carbonate of potash, washed with aerated water to superoxidize them and calcined.

PINK COLORS.

We find on the market a pale rose color manufactured in England and called there "pink color," which is used under glaze in prints on fine faience. This is an insoluble and infusible material, which is attacked by acids and alkalies. It was subjected to analysis by M. Malaguti, who found it to be composed of:

Stannic acid	78.31
Lime	14.01
Silica	3.96
Alumina	0.95
Water	0.61
Chromic oxide	0.52
Chromate of potash	0.26
Potash and loss	0.48

This analysis suggested the following formula for the production of pink color:

```
Stannic acid .........................100
Chalk ......... ..................... ........ 34
Chrome oxide ....................... .........  1 to 1.25
                        or
Stannic acid ...........................100
Chalk ............. ....... .................. ..... 34
Chromate of potash......................  3 to 4
```

Whichever formula we use we add to it:

```
Silica ................... ................. 5
Alumina ...................... ... ........ 1
```

An intimate mixture is made and is put in a crucible, which is then luted; this is exposed to a bright red heat for several hours. The resulting mass is of a very dirty red, but becomes of a beautiful rose color on washing it with water slightly acidulated with hydrochloric acid.

This color is used for the delicate ornamentation in the very agreeable rose color with which the fine English printed faience is enriched. It was very largely used in England, but was unknown in France when the directors of the royal works at Sèvres requested M. Malaguti, who was attached to the laboratory of the establishment, to determine the composition of the color and endeavor to make it. His researches resulted in the formulas above given, and the color has since been generally used and with complete success.

CHATIRON.

What is called in France "Chatiron," from the German "Schattirung," which means shading, is a material that was formerly employed for outlining the shadows under transparent colors.

This substance is nothing else but the purple precipitate of Cassius, used without a flux, when it is not of a sufficiently good quality to give satisfactory carmines, purples and violets.

It is frequently used in Germany, but hardly ever in France. It makes the outlines too brown.

HARD MUFFLE COLORS.

The hard muffle, or semi sharp fire colors have been mentioned as possessing advantages over the common muffle

colors. It remains only to indicate here the processes by means of which they are obtained. These processes are sufficiently simple. The colors are the ordinary colors, which are hardened by the addition of a certain quantity, which is found by experiment, of one of the oxides, or sometimes of all the oxides, which enter into the composition of the tender color. It is upon this principle that Bunel and Rousseau make these colors.

For these hard muffle, or semi sharp fire colors, we have retained the names and numbers adopted and used at Sèvres for the soft muffle colors, adding only to the number, in each case, the letters DD.

GRAYS.

No. 12 DD. Deep Gray.   No. 15 DD. Bluish Gray.

Black No. 12.............80.00   Gray No. 15..............80.0
Carbonate of zinc ......20.00   Carbonate of zinc.........20.0

BLACKS.

No. 18 DD. Brownish Black.   No. 19 DD. Deep Black.

Black No. 18..............80.0   Black No. 19.............80.0
Carbonate of zinc.........20.0   Brown oxide of iron......20.0

BLUES.

No. 24 DD. Azure Blue.   No. 28 DD. Sky Blue.

Blue No. 24..............80.0   Blue No. 28...............77.8
Carb. of zinc or cobalt....20.0   Carb. zinc or cobalt.......22.2

GREENS.

No. 24 DD. Bluish Green.   No. 35 DD. Grass Green.

Green No. 34.............80.0   Green No. 35.............77.8
Ox. bluish green, or Na-   Ox. bluish green, or Na-
  ples yellow, or zinc   ples yellow, or zinc
  carb ....20.0   carb 22.2

YELLOWS.

No. 41 DD. Pale Yellow.   No. 46 DD. Deep Yellow.

Pale yellow 41 B.........77.8   Deep yellow 46...........77.8
Pale Naples yellow......22.2   Deep Naples yellow.....22.2

No. 49 DD. Nankin Yellow.

Nankin yellow No. 49......**75.0**
Yellow oxide of iron......**12.5**
Carbonate of zinc.........**12.5**

No. 50A. DD. Deep Yel. Ochre.

Yellow ochre 50A.........**75.0**
Yellow oxide of iron......**12.5**
Carbonate of zinc........**12.5**

No. 50 DD. Pale Yellow Ochre.

Pale yellow ochre No. 50..**75.0**
Yellow oxide of iron......**12.5**
Carbonate of zinc.........**12.5**

No. 50B. DD. Very Deep Yellow Ochre.

Yellow ochre No. 50 B...**75.0**
Yellow oxide of iron......**12.5**
Carbonate of zinc.........**12.5**

REDS.

No. 55 DD. Orange Red.

Orange red No. 55........**80.0**
Red oxide of iron.........**20.0**

No. 66 DD. Violet Red.

Violet red No. 66.........**80.0**
Violet oxide of iron......**20.0**

No. 58 DD. Blood Red.

Blood red No. 58.........**80.0**
Red oxide of iron.........**20.0**

No. 66A DD. Deep Violet Red.

Violet red No. 66A........**80.0**
Violet oxide of iron......**20.0**

BROWNS.

No. 67 DD. Red Brown.

Red brown No. 67........**80.0**
Brown oxide of iron......**20.0**

No. 70 DD. Wood Brown.

Brown No. 70............**80.0**
Carbonate of zinc........**20.0**

No. 68 DD. Reddish Brown.

Reddish brown No. 68....**80.0**
Brown oxide of iron......**20.0**

No. 75 DD. Sepia Brown.

Sepia brown No. 75......**80.0**
Carbonate of zinc........**20.0**

To make these colors it is sufficient to grind up the colors with the colors already made. We must, however, melt the mixture if we add cobalt.

These are the recipes employed by Bunel and they are vague enough. It appeared to me that it would be possible to improve on these by using well known elements and different fluxes to those employed for the soft muffle colors.

The idea of painting for a semi-sharp fire belongs entirely to Francois Richard, painter on the staff of the royal Sèvres works; the advantages of this system are incontestable, as by it the hard porcelain gets the decorative advantages of

tender porcelain, which is so superior from the decorative point of view.

As we know, the general procedure in painting on hard porcelain is the same as in water color painting, to obtain our high lights by leaving the original surface clear. Very rarely, indeed, do we produce a high light by laying an opaque white upon a color, the same as is done in oil painting, it is only in quite exceptional cases that we do this, to repair a defect or to modify a tint.

By the old system the palette was composed of two kinds of colors, which the artist could mix at pleasure, the first kind was deep, and intended to give vigor to the painting, without any danger of scaling off and possessing sufficient gloss in themselves when used alone; the second set of colors was intended to be used for diluting the first a- d for glazing them in the high lights. The glaze of hard porcelain does not soften at the temperature of firing, consequently does not assist at all in glazing the colors.

Richard modified somewhat this general principle. In the first place he composed his palette in such manner that in a large number of cases the first sketch did not show any definite glaze, parts of it were even completely matt, and it was only for the retouching fire that he laid on a flux, which seemed to play the same part that the varnish does in oil painting.

We find, therefore, in the series of colors prepared by Richard, invariably three types for each separate shade of color, the one is extreme, the second supplies a mean and the third, almost colorless, serves as a flux for the first.

SHARP FIRE COLORS.

This designation, high temperature would perhaps be better, ordinarily, applies only to the colors of hard porcelain, which can be fired at the same heat as the glaze of the porcelain itself; though we think that this term ought to be extended to all those which fire at the same temperature as the glaze, no matter what the pottery may be upon which they are applied. Thus the colors placed with colored glazes of common earthenware and the fine faience, with colored enamels of faience, with the colored glazes of stoneware and of tender porcelain, if they are fired with these glazes and not

in a separate, weaker, fire, generally known as a muffle fire, play absolutely the same part as those which are applied under, in, or upon the glaze of porcelain, and which is fired, like it, at one of the highest temperatures employed.

These colors, which are nearly always spread evenly over a large surface, bear also the name of ground colors; they become less and less numerous in proportion as the pottery on which they are applied requires a stronger fire; thus there is not much variety in the sharp fire, or high temperature colors for porcelain, while on the other hand those of faience and tender porcelain are almost as numerous as the muffle colors; in fact there are few metals which give oxides capable of resisting the high temperature required for porcelain without losing their distinctive colors, and still fewer which preserve their tints unchanged. We may point to a few examples in this category, iron, copper, manganese, of which the colors of the oxides or the salts are so brilliant and so varied, but each of these only produces one oxide capable of resisting a high temperature.

We shall now treat of the different colors for high temperature, but will confine ourselves, almost entirely, to those for porcelain. We should remark here that the manner of applying these colors will be treated later. The way in which the color is applied has, sometimes, a very strong influence upon the variety, or tint of the color itself.

NUT BLACK.

Black for the sharp fire is obtained from two materials, uranium and manganese.

The purest is that which is composed of nothing but protoxide of uranium, 1 part to 22 or 23 parts of glaze.

What may be called grayish-black is obtained by using oxide of iridium, its tint always tends to gray; it will often go through the thickness of the porcelain body and stain the inside of the ware an uneven gray tint.

BLUISH-BLACK.

This results from a mixture of cobalt blue and oxide of manganese, either by mixing the two oxides and melting them together, or by painting one over the other. If we have a piece of an undecided blue color we can convert it into a fine

and briliant black by covering it with a thin coat, having for
its base iron and manganese.

This is obtained in different shades, according to the pro-
portions used of dried chloride of platinum, yellow-brown and
flux.

The best way to make it is to dissolve, or rather to dilute,
from 50 to 150 grams of dry platinum chloride in 10 liters of
porcelain glaze; acording to the depth of tint obtained, it is
called pearl-gray, mouse-gray, or smoky gray.

It is put on by dipping; it can also be done by laying on a
solution of platinum. Care should be taken to oil the piece in-
side, to prevent the solution passing through the body of the
ware.

BLUES.

All blues come from cobalt, either alone, of different in-
tensities, or mixed with other colors.

INDIGO BLUE, ALSO KNOWN AS DEEP BLUE, OR ROYAL' BLUE.

This is the purest, and it is this which, well prepared, well
laid on and finished, gives the color which is most sought
for, either on hard porcelain, tender porcelain, enameled
faience, or stoneware, etc.

We believe we are able to reduce to the following formula
the numerous recipes which have been given for preparing
indigo blue, or the sharp fire blue for hard porcelain.

This formula is very brief and it may be considered to be
insufficient, but it must nct be forgotten that we are taking
for granted that the oxide of cobalt is already prepared and
that it is pure. It is in this preparation of the oxide that all
the difficult and essential part exists.

To make the blue we take:

       Oxide of cobalt, pure and dry..........20 or 25

       Feldspar for glaze....................80 or 75

When the oxide of cobalt contains arsenic we take two
parts of feldspar to one of oxide of cobalt, these are tritu-
rated and exposed to the heat for biscuiting porcelain; we
get neither a molten nor a puffed-up mass, but one that is
agglutinated. In order to lose as little as possible of the

material we first give the interior of the crucible in which the calcining is done a thin coat of refractory clay. The mass, which will be found in the shape of a rose-blue button at the bottom of the crucib.e, is taken out, washed and crushed.

For some years past I have constantly made the deep blue with oxide of cobalt that comes from Birmingham, England. In consequence of the purity of this oxide and its coloring power, it was necessary to modify the formula. I take:

Oxide of cobalt.............................14
Covering, or pegmatite glaze.................86

The blue, prepared according to the first formula, is good and glosses well, it very rarely exhibits the species of geodetic crystallized and rose colored marks which present themselves, too often, in the blues made from the oxides of cobalt prepared in the laboratory at Sèvres. It has not been noticed that these ground colors have an unusual tendency to turn pit.

An important thing is to be sure of the purity of the oxide of cobalt and that there is no nickel in it. The smallest trace of the latter oxide will produce peculiar brown colorations, which show right through thin pieces of ware, through cups and even through plates.

The vapor of nickel spreads beyond the portions which have been covered with blue, particularly where the ware is fired in a reducing atmosphere. The firing should be done with wood and with a good draft. I think the explanation of this is that the nickel volatilizes much more readily and is carried off when in the metallic state; in the condition of ox· ide it is more stable. A similar fact is observed in connection with zinc, which is volatile as metal, but resists the fire in the state of oxide.

When we frit the mixure of pegmatite and cobalt oxide, it is well to avoid too intense heat, which causes the blue to become "short" and difficult to work.

Formerly the mixture of feldspar and oxide of cobalt was passed through the sharp fire. .There was complete fusion, accompanied by considerable ebullition and a notable loss in the weight of the materials used. M. Marignac showed that this loss, which is very small for the pure oxide of cobalt, is explained by the transformation of the peroxide, which is mixed with the oxides, into protoxide and that it is greater

and more variable when the oxides of cobalt contain arsenic than when they are pure, in such case the loss is due to the volatilisation of the arsenic acid.

Considerable precautions have to be taken in order to get a fine blue; these precautions may appear tedious, but success depends upon their being observed. We have endeavored to make use of the rose oxides found on the market, as is done in several factories in France and Germany by applying them directly to the glaze, but have never been able to get the same qualities of blues that we obtain from the oxide used in the simple way we have just described.

The oxide of cobalt which is absolutely pure does not appear to give such a bright blue as that in which a little silica or a little arsenic remains; its color seems too deep and black.

When the blue does not get enough fire it does not develop well; it becomes specked with little violet stains, or else is black and, as it were, shaded, with hardly any gloss. It is proved that these defects are due to firing at too low a temperature by the fact that when we re-fire it at a higher temperature the blue shows its proper color and translucency.

Blues in the sharp fire are subject to quite a number of faults, for which it is sometimes difficult to find an explanation. Among the more notable, and those which appear to belong to this color, we may consider the stains, bubbles, and the recession, the drawing back of the color from the surface of the ware on which it is laid.

A blue, after firing, sometimes appears covered with large gray stains, crystalline and metallic, which Laurent has recognized as being either arsenide of cobalt or metallic cobalt; these are due to the reduction of the arsenate of cobalt by the reducing gases of the porcelain kiln.

The formation of minute bubbles, also called pitting, is one of the most serious and unfortunate faults, for we do not know to what to attribute it nor how to correct it. In the case of bubbles the blue, on coming out of the kiln, looks as if it had boiled, more or less; its surface is rough or perhaps simply dull, from the presence of a multitude of minute prominences and pin holes, which rob it of all brilliancy.

It is not to the composition of the blue that we must attribute this defect, as may be seen from the two quite different kinds of tests that have been made; taking first the careful and delicate analysis made by A. Laurent; it will be noted

that it indicates nothing that is not found in the very finest blue. This is a blue showing bubbles, which was taken from a piece of ware having that fault and was consequently mixed with its feldspathic flux, it analyzed as follows:

Silica	68.0
Alumina	14.1
Peroxide of iron........................	1.7
Protoxide of cobalt.....................	5.6
Lime......	1.6
Potash	9.0
Manganese ....Trace	

Another proof that the fault is not in the blue is that, on another part of the same piece of ware, the blue is well glazed and not in the least bubbled. Then an oval plaque has one of its ends bubbled and pitted while the other end is perfect; we can see the same thing on a cup, on a plate, etc.

We find that this fault never shows itself except in places where the color is laid on thickly, thus a blue, evenly laid on and very thin, never pits in saucers belonging to tea sets; it is always the middle of the bottom that is pitted and hardly ever the border, where the color runs down and is thin. Finally that which proves most conclusively that it is due to the influence of the thickness of the color, is the behavior of the blue, which is arranged to represent lapis-lazuli; the thin and pale color, imitating the veins of the stone, is never pitted, while the fault is frequently met with in the more strongly colored parts, which are surrounded by the veins.

We ought to attribute this defect, first to the temperature to which the piece has been raised and which may vary for any one piece, in consequence of the draft driving the fire more strongly against one side of the pile of saggers than the other. Second, to a peculiar condition of certain blues which renders them more sensitive to slight differences in the degrees of temperature.

We have no certain means of correcting this defect; refiring the piece, whether it be rubbed smooth, or covered with another layer of blue, does no good. The nearest approach to an improvement has been the application of a thin coat of flux which, after firing, evens the surface a little.

Another defect of the blue in high temperatures, which is

the more serious because it cannot be foreseen nor avoided, is the recession, the shrinking away of the color from the surface. The blue laid on a glaze will sometimes draw itself together, leaving places entirely white. This action is similar to that of a liquid upon a surface which is repellant to it, as for instance, water on a greasy plate.

Why, in certain cases, should the same blue, laid on in the same way, with the same essence, draw together, while in others it stays in its place? This cannot be attributed to the essence, though we were at one time very much disposed to believe it might be, but it may be due to humidity, which, at the commencement of firing, interposes itself between the color and the glaze of the body. Acting upon this idea we had some blue dried in a muffle before using it in the sharp fire, and although this method did not meet with constant success, it was remarked that, in a number of cases, recession of the color was avoided.

These are the principal faults belonging to blue, in its preparation and its firing. It also presents some others, but they appertain to the laying on of the color; they are common to other colors of the sharp fire and will be examined in their proper place.

AZURE BLUE.

This has a tint which is more azure and less transparent than indigo blue; it approaches, somewhat, to the fine enamel blue of some faiences. It owes this fine tint to oxide of zinc and a little alumina. It is composed of:

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Oxide of cobalt........................... 1
Oxide of zinc...............................12
Alumina ............. ................ ..... 1
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It is laid under the glaze.

PALE BLUE.

This is also called agate blue because it has a tint approaching that of some of the chalcedonies. It was formerly made with a small quantity of cobalt oxide and one or two parts of glaze, melted together, mixed by well grinding with about 30 parts of glaze and sifted on. This uncertain process has been replaced by the dusting on process, which is much simpler. In this case a very thin coat of indigo blue is laid on.

After the simple blues, that is to say, those in which no other oxide enters but the cobalt, come the blues of various tints.

GREENISH BLUE.

This is obtained of a tint which tends to bluish, that is to say, in which the blue dominates over the green.

> Oxide of cobalt..............................1
> Oxide of chromium..........................2
> Alumina 3

It is easy to give the color all the shades, more or less bluish or greenish, by varying the proportions of the coloring oxides, but, in general, it must be remembered that the cobalt, being a powerful colorant, if mixed in equal proportions with chrome oxide, overcomes the green by its blue color.

The richness of a tint depends essentially upon greatest possible fineness of division of the particles of the oxides, or rather of their union in a state of incipient combination; chrome oxide strongly calcined will with difficulty give a bluish color in combination with oxide of cobalt; while the cobalt oxide cobalt ground in water then mixed on a palette with dry chromate of mercury, the whole dried and calcined always combines and produces a tint of remarkable richness.

We also get an analogous oxide by operating in the following manner:

One gramme of carbonate of cobalt, well dried, is weighed and dissolved in hydrochloric acid. Caustic potash is poured in slightly to excess, which precipitates the cobalt oxide hydrate. This is washed and kept in a wet state.

In addition, we take 10 grammes of crystallized yellow chromate of potash, this is dissolved in pure water to this hydrochloric acid and a little alcohol are added and the whole is boiled; acid and alcohol are added in small quantities at a time so long as chlorine is given off, which is easy to recognize by its odor. When the gas has disappeared the solution is taken off the fire and allowed to cool. The chromium chloride thus formed is precipitated by ammonia and the chrome hydrate is washed; this hydrate, after well washing, is mixed on a palette with cobalt hydrate, prepared as before described. The mixture is allowed to dry, and when dry it is calcined in a good fire.

This ground color can be used either on the glaze or under

it, but it has more gloss and consequently more brilliancy when under the glaze.

TURQUOISE BLUE.

This has the yellowish-green tint of certain turquoise and approaches somewhat to the bastard color of the old tender porcelain of Sèvres, which is now so much prized. This is composed of one part of a bluish green, to which is added three parts of carbonate of magnesia; to the mixture we add a little glaze in powder.

These colors take different tones according to their chemical condition, their molecular state, the preparation of the ingredients and the firing they receive. We select from among them those which are the most suitable.

GREENS.

The first green, which may be called emerald green, although it does not possess the pure green of that beautiful stone, is made with the chrome oxide prepared according to the instructions given in "Brick" for September, 1895, page 165. This is used without any addition, and is either dusted on taking care to give a very thin coat, or is applied upon the biscuit; in the latter case it is laid on with glaze or by dipping. In either way, but particularly the first, it is susceptible of a great variety of shades, which is due, first, to its state of division, and, second, to the influence of the fire. Thus it sometimes loses its emerald color and its glaze and becomes dull, almost black. This fault can be corrected, at least in part, in those oxides in which it is met, by adding either alumina or magnesia in the proportion of four parts of alumina to six of the chrome oxides; these are carefully ground together and calcined in a biscuit fire; they are placed in the wad and dusted on with a small quantity of glaze. It must be put on of a suitable thickness, or else bubbles will be formed. These same oxides, without the addition of alumina, give a green olive tint, which is sometimes useful. By adding oxide of zinc to the green that is put on by dipping, we get a pure apple-green color which is very agreeable.

CELADON GREEN.

This is a color that is in great demand, because, for a long time it could only be made properly in China and even at the

present time it is from that country we get the finest shades of this pseudo color; it is a greenish tint mixed with yellow and blue.

This is the way in which we approach the nearest to the Chinese, which certainly cannot be a color that is fired at as high a temperature as our hard fire, and which is, doubtless, made differently to the following prescription, as the Chinese are not acquainted with chrome oxide.

We make a mixture of oxide of cobalt 1 part and oxide of zinc 50 parts and calcine it in a biscuit fire. Of this mixture we take 750 grams, to which we add chrome oxide 250 grams; this is mixed with about 20 liters of glaze, and the color is put on by dipping. The tint may run more to green or blue, according to the relative proportions of the two oxides.

STRAW COLOR.

We do not possess a fine yellow for the hard fire. Oxide of titanium, or, rather, titanic acid, gives a straw yellow, running sometimes to reddish, but it has the serious inconvenience of changing its tints with the slightest difference, either of temperature or of the oxidizing action of the fire. In consequence of this we are not able to rely upon an equality of tint, not merely on two pieces fired separately, but even on one small piece, such as a tea cup or saucer.

The preparation of the color is simple. It consists in taking titanic rutile in prismatic crystals, crushing them very finely and washing the powder with hydrochloric acid, to get rid of any iron, which is often interposed between the crystals. The fine powder is mixed with about three parts of feldspar.

Arnoux, of Toulouse, mixed tungstic acid with oxide of titanium and produced a yellow ground with a tendency to jonquil yellow. It is a pretty color, fairly bright and of an even tint. Arnoux uses it on plaques of about four inches and for ornaments on portions of vases., but if it is laid on a curved surface it does not preserve its even tint like it does on the flat.

ROSE ISABELLE.

This is one of the prettiest grounds fired in a hard fire, but it is very difficult to get the rose tint and as equal as could be wished. This color is made from gold. There are several

methods of preparing it, the first, where the color is put on by dipping, is Bunel's. It consists in mixing with 10 liters of porcelain glaze 20 to 30 grams of a solution of gold in aqua regia, concentrated to a syrup-like state.

Another process, which is more economical, is due to P. Nouailler; one part of a solution of gold in aqua regia is added to five parts of glaze and five parts of alumina. The whole is evaporated to dryness, at the same time mixing the materials well with a glass spatula. The mixture is sharply calcined in a porcelain crucible. The mass, which is rendered homogeneous by mixing, is ground and we get a fine rose-colored powder; this is laid on by dusting.

Finally a rose-colored ground that is made from gold is produced by applying a concentrated solution of gold upon the biscuit, but care must be taken to well oil the inside of the piece to keep the solution from going through. The oil is burned off in a biscuit fire and the glaze is then put on. According to the proportions, that is to say, the degree of concentration of the solution, we get a ground that is rose-colored, or grayish violet.

RED BROWN, OR TORTOISESHELL.

The ground, which is similar to the shell of a tortoise, whence it receives its name, is one of the easiest to make and is in very general use on the commonest ware; it is often used for sanitary ware to cover the dirty gray color of the body.

It is composed of:

Oxide of manganese.............................15
Umber 20
Porcelain glaze.................................65

The umber is calcined and the materials are well mixed by grinding and sifting; they are then melted in a crucible in a sharp fire; the ingot is pulverized and the brown powder, which should not be too fine, is laid on by dusting onto a mordant or tacky surface. It is fired on a part of the kiln where the fire is most moderate. This ground color varies according to the temperature, and may be too light, if it has had too little fire. It also varies according to the nature of the manganese and the umber.

REDDISH LAKE, OR BISTER.

This is a ground of a deep red brown, imitating the red lac of China. It very seldom has a bright glaze. It takes gilding well and particularly platinum. It is composed of 75 parts feldspathic glaze and 25 of red oxide of iron. These are melted together, powdered, and the color is sifted onto a tacky surface, as in the preceding.

CHESTNUT BROWN.

This brilliant and warm color is a modern one. It can be obtained directly by using natural chromate of iron, but this material is too variable, in consequence of the inequalities in the composition of this rock. The color is much finer when put on by dipping than in any other way; we have therefore chosen the composition which is more suitable for this process. This consists of:

Artificial chromate of iron...............8 hectograms (28 oz.)
Green oxide of chromium...1 to 2 hectograms (3½ to 7 oz.)

The whole is mixed in about 20 liters of glaze.

A chestnut brown, which is very fine, in the warmth of its tint and its brilliancy, has a little manganese added to the chromate of iron. According to the quantity of chromate and its purity we can produce deep browns, which are almost a greenish black, by adding a little of the oxides of cobalt and of iron.

ANNOTATIONS UPON THE COLORS.

There has been considerable talk about painting in enamels and the difficulties met with in this kind of painting, inasmuch as the colors change when fired, and we must lay them on according to our judgment as to what shade and what effect the color will have after it is fired. This is a real difficulty in enamel painting, properly so called, that is to say, upon an excipient which contains oxide of tin or oxide of lead, which softens in the fire and which, in consequence of this softening, reacts upon the metallic oxides of the colors that are laid on. It is also a difficulty with all pottery, the glaze of which contains lead, such as the common glazed pottery, fine earthenware and enameled earthenware, and the artificial, tender porcelain called old Sèvres, when the temperature has softened the glaze. All colors do not change on the lead glazes, such as

those of fine and enameled earthenware and tender porcelain, but only some of them and their mixtures with other colors. These are the iron reds and yellows, the copper greens, the iron browns, the roses and purples obtained from gold; these latter always change their color in the fire, no matter what the excipient on which they are placed.

We have, earlier in this work, shown the way in which the muffle colors can be divided, considering them from the point of view of the state in which we use them, that of simply mixing their ingredients, or of the more intimate union of these ingredients, obtained either by merely fritting, or by completely melting them together. We give here the classification of all these colors.

1st. Colors which are not fused:

No. 23 Turquoise blue.
No. 25. Ultra-marine blue.
No. 34. Bluish green.
No. 35. Grass green.
No. 36D-36T. Dark greens.
No. 39. Brown green.
No. 45. Uranium yellow.
No. 49. Nankin yellow.
No. 50. Pale yellow ochre.
No. 50A. Deep yellow ochre.
No. 50AV. Fine yellow ochre for greens.
No. 50B. Very deep yellow ochre.
No. 55. Orange red.
No. 58. Blood red.
No. 59D-59T. Gold carmines.
No. 60. Purple.
No. 62D-62T. Carmine reds.
No. 63D-63T. Lac reds.
No. 65 Gold violet.
No. 66-66A. Violet reds.
No. 67 Red Brown.
No. 68. Reddish brown.
No. 70. Brown for woods.
All the hard colors marked DD.

All these colors fire with the same shades as when laid on, except the gold colors, which are very delicate, and as there is risk of their changing, we prefer not to fuse them.

2nd. Colors that are fritted:

    No. 13. Reddish gray.

    No. 14. Pale gray.

    No. 15. Bluish gray.

    No. 18. Brownish black.

    No. 70. Brown for woods.

    No. 75. Sepia brown.

These do not retain the colors as laid on if they are fused, they generally take a tint that is too deep, and firing will not bring them back to the shade desired by the artist.

3rd. Among the colors which are fused we enumerate the following:

    No. 12. Deep gray.

    No. 17. Grayish black.

    No. 19. Deep black.

    No. 22. Indigo blue.

    No. 24. Azure blue.

    No. 28. Sky blue.

    No. 41B. Pale yellow for browns.

    No. 42. Jonquil yellow.

    No. 43. Deep yellow for browns and greens.

    No. 46. Deep yellow.

    No. 47. Yellow for flesh tints.

    No. 52. Chrome orange yellow.

    The copper greens.

    The manganese violets.

None of these colors will fire with the same tints as they possess when they are laid on unless they are first fused, as the coloring principles do not give the desired tint unless they are completely combined and the temperature at which this combination takes place is frequently higher than that at which the colors are fired on the ware, so that they could not be used without a preliminary fusing.

THE METALS.

Several metals are employed in their natural state for the decoration of pottery. For this purpose it is necessary that the metal should be unchangeable under the influence of fire and the atmosphere. These requirements reduce to three, the number of metals that can be employed. They are gold, platinum and silver. We can use copper, but its brilliancy and

color soon change under the influence of the sulphurous vapors so frequently diffused in our habitations. Silver is almost in the same case, for, notwithstanding its brilliant metallic white, the facility with which it can be used and its moderate price, it has been almost entirely abandoned as a substantial and durable means of decoration.

There have been placed on the market, and chiefly in Paris, pieces of hard porcelain of which the principal decoration consists of ornaments and grounds of matt silver with guilloche or engine turned markings. This metallic matt, of a fine white, is enhanced by ornaments in blue or any other striking color, interspersed with it or surrounding it, producing a very agreeable effect, which, at the first glance, appears like the brightness of a pale pearl without any iridescent effect. This silver can also be burnished, and it has the precious property of resisting the action of the sulphurous acid in the air.

This resistance to the strongest sulphurous emanations is due to the superposition of a very thin coat of gold upon the silver; this is laid on with a brush before putting it in the muffle fire, where, by means of a cherry-red temperature, we melt the small quantity of flux which fixes these two metals onto the porcelain. The complete success of this method of silvering depends upon the skill of the artist and on several empirical precautions, of which the following are the principal:

The silver should be dissolved in an acid diluted with plenty of water, precipitated slowly by the copper and well washed. It is necessary that the silver, laid on the white of the porcelain, or upon a ground of hard color which does not contain any color made from gold, should be put on thickly and be left in this state for 24 hours before putting on the thin coat of gold solution; finally the whole should be fired at a moderate heat.

All metals that are to be laid on with a brush must be in such a fine state of division that they lose their brilliancy and appear in the form of a brown or even a black powder. This powder is, nevertheless, metallic and its black color is due to the extreme state of subdivision of the metal. It should be diluted and rubbed up in a viscous material which is, depending upon circumstances, spirit of turpentine mixed with fat oil, or thick gum water.

Chemical solution is the method usually employed for bring-
ing gold and platinum to this state of division. The method
of dissolving it is the same in each case; nitro-muriatic acid,
commonly called aqua regia, is used, but the way in which the
metal is precipitated differs for each. We will explain how the
metals· are prepared.

PREPARATION OF GOLD.

Gold can be prepared by two quite distinct methods; in the
one it is precipitated from its solution by the sulphate of pro-
toxide of iron (green vitriol), in the other the precipitation is
effected by proto-nitrate of mercury. In both cases the gold
is in the metallic state, extremely finely divided, in the sec-
ond case it is in a still finer state of division, but the gold
which is prepared with protoxide of iron should be preferred,
as it gives a more substantial gilding, in consequence of the
larger quantity of gold which is employed.

Precipitation of sulphate of protoxide of iron:—We dissolve
100 grams of gold in 1800 grams of aqua regia. The aqua
regia consists of two parts of commercial hydrochloric acid
and one part of ordinary nitric acid. The gold dissolves in
this without any assistance, and when the solution is com-
plete it is diluted with a large quantity of water; to this is
added an equally weak solution of sulphate of protoxide of
iron, which has been freshly prepared and filtered. This
throws down the gold and the precipitate is allowed to remain
at the bottom of the vessel. The liquid is decanted off and the
precipitate is washed with boiling water to get rid, as much as
possible, of the iron; the last traces of this that may be present
are removed by a little hydrochloric acid, but the action of this
acid seems to render the molecules of gold coarser and harder,
so that they will not flow so smoothly from the brush.

The drying of the gold should be done carefully and at a low
temperature. This can be done on the sand bath, but it is
safer on the water bath. The drying must, however, be com-
plete. If we heat it too much the gold will become hard and
difficult to crush and to use.

This preparation, although it appears so simple, requires
sufficiently minute care in order that the gold should possess
its qualities of facility in use and consequent economy and of

becoming brilliant when burnished. The practice which has constantly given us these qualities is that which we have indicated and which it is well to adhere to closely.

Precipitation by mercury:—Just before using it we prepare a solution of proto-nitrate of mercury, by treating 150 grams of distilled mercury with 400 grams of ordinary nitric acid, without any addition and allowing the reaction to take place slowly and, as much as possible, without the assistance of heat. At the same time we dissolve 25 grams of gold in aqua regia. In each of the two liquids heat has spontaneously generated, and, without giving them time to cool, we pour the proto-nitrate of mercury into the gold solution. The mixture becomes clouded and a thick deposit of numerous flakes of metallic gold is deposited; this is of a brown-yellow color, and the yellower it is the better. It is washed thoroughly with boiling water, and the same precautions must be taken in drying it as with the other preparation. While drying it must be stirred with a glass rod to prevent the gold being thrown out of the capsule in which it is contained, but we must avoid, as much as possible, rubbing it against the sides of the vessel or scales may be formed, which prevent it working smoothly when used.

In whichever way the gold is prepared, when it is thoroughly dry, it is ground carefully on a very clean glass, diluting it with spirits of turpentine mixed with a little fat oil. If the grinding is done by an inexperienced person with a heavy hand, the molecules of gold will be pressed together and reunited, producing a mass of scales.

Practice in the use of gold has revealed several singularities, which it is well to know. Thus, observation has taught gilders to let the ground gold lie for some time on the slab before using it; we have verified the truth of this by our own experience. It has also been noted that on adding a large quantity of fat oil the gold, while more viscid and difficult to lay on evenly, produces a very much finer matt, after firing at a high temperature. Ground in this way the gold, mixed with its flux, is laid on with a brush.

The process of gilding usually employed at Paris consists in mixing a small quantity of oxide of bismuth with the gold precipitated by proto-nitrate of mercury; this serves as a flux and permits the metal to fix itself, by means of the fire, to the

surface of the porcelain. The gold is applied in very thin coats, so that this kind of gilding is not expensive, but it is not substantial and soon wears off in use.

Several processes have been proposed to render the gilding more durable without increasing its price to a great extent. Rousseau first lays on a coat of platinum mixed with flux, which he then covers with a very thin coat of metallic gold. This process gives a solid-looking gilding, but which does not wear well, as the color of the gold is modified by that of the platinum beneath, which soon becomes apparent when the article is used. Another method used by Grenon consists in putting on two coats of gold one after the other, each with a special flux and in different proportions. The first coat is fired at a high temperature and is then polished; upon this a thin coat of gold, precipitated with mercury, is laid on and fired in the ordinary manner. This gilding burnishes easily and becomes very brilliant. Experiments made at Sèvres proved that it resists rubbing with hard substances which would destroy ordinary gilding.

Gold which is employed for the decoration of pottery is also prepared mechanically ,and by this means we obtain a matt gold, which, to look well, must be fired at a temperature that is exactly suited to it and which is generally lower than that at which dissolved gold is fired, but the preparation of the gold, sufficiently finely divided, by this method is so expensive that the price of the gold is almost doubled. As it is usually put in mussel shells, this kind is called shell gold. It is prepared from pure gold leaf; the leaves are ground on a slab with honey, sugar, salt, or any other divider which warm water can easily remove. A man skilled in this work cannot grind more than 60 grams of gold per day. When the gold is ground it is put in a vessel with hot water and is stirred up to dissolve all the soluble matter in the water. In this operation the greater portion of the gold, on account of its tenuity, floats in the liquid; this water, charged with the finest gold, decanted, leaving the coarser gold at the bottom of the vessel. This washing and decantation is continued until all the divider is removed. The gold in the water is allowed to stand until it settles and the clear water is decanted. The gold is dried on a sand bath and is used in the same way as that prepared from a solution by precipitation.

In the gilding of the ancient tender porcelain of Sèvres an extensive use was made of shell gold. When it is prepared with a gold which is without alloy, or contains only a few thousandths of silver, the gilding is rich and very brilliant.

The solvent for shell gold is mostly honey water or gum water. Honey has two serious disadvantages—it attracts flies, which, with their feet, spread the gilding about, destroy the fineness of detail and spoil the work of the artist; in the second place, honey ferments, and in the process of fermentation gives off a gas which lifts up the gold and prevents its adherance to the porcelain.

Gum has fewer disadvantages, but it must be used in a fluid state and very cautiously.

In either case, whether we use gum or honey, the gilding must not be applied to any part that is not absolutely free from grease, or the gold will come off in scales and will not hold at all. We have prepared a good composition for working the gold, by adding to the mordant or "tacky" of Father Hippolyte, which we will describe later, a little solution of gum arabic; this is called mucilage for gold.

The gilding which is to imitate old Sèvres is made by preparing the shell gold from gold which is alloyed with some thousandths of copper. Under the action of the fire the copper contained in the gilding oxidizes and gives the gilding a dull appearance, which collectors attribute to the age of the piece.

As to the grinding of the gold, it is a strange thing that no one has succeded in doing it well and economically other than by hand; all attempts at doing it mechanically have been failures and also in doing large quantities at a time.

PREPARATION OF PLATINUM.

Metallic platinum in a very finely divided state is obtained by dissolving the metal in aqua regia. It is precipitated from its solution by sal ammoniac; we thus obtain a yellow salt in a powdery form. It is but slightly soluble in water and is insoluble in alcohol. It decomposes at a red heat, and the residue is a very pure, spongy platinum. In decomposing it gives off nitrogen, hydrochloric acid and sal ammoniac. The salt contains 44.32 per cent of platinum and its composition is sal ammoniac 24.1, bichloride of platinum 75.9.

It is upon its property of decomposing in heat that the

preparation of pulverized platinum depends. We put the salt in an earthen crucible and heat it to incandescence. When no more vapors are disengaged we stop the fire and take from the crucible a spongy mass, which is very porous and possesses little cohesion. To divide it still further, we can grind the yellow salt with common salt, before calcining, and this is removed by washing with boiling water. The platinum prepared in this way is black. It is ground and used the same as gold, with a similar flux.

Platinum is also put up in shells and presenting a bright metallic appearance, which does not change.

These metals, used as ornament, or as a ground, must be fixed by the action of fire, but this action will not suffice to make them adhere to pottery the glaze of which is an earthy covering, like that of hard porcelain, some stoneware, etc., which does not soften at the temperature suited for firing; it is therefore necessary to add some material which will run at this temperature and serve as a connection between the metal and the ware. Borax, or, more commonly, oxide of bismuth, is used for this; at Paris they also use a simple mixture of carbonate of lead and borax, or boracic acid. Some gilders even use nothing but carbonate of lead. A tenth or a fifteeenth of the flux is put on the palette in the gold before rubbing it up with the turpentine.

As for pottery with a lead glaze, such as common earthenware, fine earthenware, tender porcelain, etc., the enamel or glaze of the ware is a sufficient flux to hold the metal in place.

METALLIC LUSTERS.

This is a species of decoration in which the colors, often iridescent, have something of a metallic brilliancy, or in which the metals, in an extreme state of subdivision, are put on like colors and get their metallic brightness from firing, without having to be burnished to make them polished and brilliant. We have, a few pages back, stated the essential conditions which must be fulfilled by the metals used in this species of decoration and do not need to repeat this; we will only recall the fact that it is to the excessive thinness of the metallic coat that the desired luster is due.

This extreme thinness is generally obtained by using solutions which contain very small quantities of the metal that

produce the luster and laying the solution with a brush upon the piece to be decorated.

PEARL LUSTERS AND IMITATIONS OF PEARLS.

It is well known that pottery can receive a peculiar kind of decoration, known as luster or chatoyant, but the substances capable of giving the characteristic iridescence of these prod· ucts are very few in number. Apart from gold in one of its states and silver as a chloride, when it is fired in a reducing heat on blue, called hard-fire blue, and apart also from oxide of lead and oxide of copper, under conditions which are not yet well known, no metal applied to pottery is capable of producing at will the iridescence which we meet with in several natural products.

M. Brianchon, a decorator of porcelain of Paris, has very successfully modified the conditions under which the lusters we speak of are prepared, and has rendered them susceptible of communicating to the various ceramic objects to which they are applied the colors of gold, of white and colored pearl and the iridescent and changing reflections of the different shells that we find in nature.

Brianchon observed that oxides of bismuth, laid on in a thin coat, possessed in the highest degree the property of decomposing the white light reflected from vitreous surfaces, and that it communicated this to several of the oxides with which it could be mixed, and augmented it in those bodies which already possessed this property of decomposing light. The methods of Brianchon are based upon this double property of oxide of bismuth, and as this material developes its distinctive characteristics in an oxidizing temperature, it gives us the possibility of adding this kind of decoration to porcelain which is already ornamented with gilding and with painting in the usual vitrifiable colors.

To get complete and satisfactory results the oxide of bismuth should spread easily and evenly. It should have, as a vehicle, a siccative mixture which is destroyed by the fire without affecting the color nor producing blisters. The best way is to employ it in an oily form; it is thus that the gold liquid is prepared for bright gold.

In its pure state the bismuth compound produces a white pearl; mixed with other oxides or laid on over them it fur-

nishes colored pearls; the other oxides, in such case, are also laid on in liquid form with a suitable oil as vehicle.

The methods therefore comprise two distinct operations, the preparation of the bismuth composition, which we will call bismuth luster, and the preparation of the colored lusters, that we will designate as pearl lusters. These are obtained by first mixing the bismuth luster and then the superposing of the same material, after a preliminary firing.

Brianchon patented his process, but the patent has long since expired, and we will take from it the following details of the preparation of what he calls the flux and the color:

Preparation of the flux: Bismuth luster; an oily composition of bismuth. We take, by weight, 10 parts of crystallized nitrate of bismuth, 30 parts of colophonium (rosin) and 75 parts of essential oil of lavender. The 30 grains of rosin is put in a capsule on a sand bath and gradually heated until the whole is melted; we then add, in small quantities at a time and stirring all the time, the 10 grams of crystallized nitrate of bismuth. As soon as the liquid begins to turn brown we put in 40 parts of the essence of lavender, in very small quantities at a time, stirring continually so as to have an intimate mixture. The capsule is taken from the sand bath and allowed to cool, then the remainder of the essence of lavender is added, while still stirring it. It is allowed to stand for a time and any undissolved portion is skimmed off, as this would interfere with the easy and regular use of the liquid. The liquid itself is thickened to the right consistency, either by exposure to the air or by the application of a gentle heat.

Preparation of the colorants: For pearl lusters, white and colored, the materials are borrowed from the inorganic kingdom and have for base the salts of platinum, silver, palladium, uranium, iron, manganese and gold to produce the rich tints of shells or the reflections of the prism. The following is the way in which the principal ones are prepared: In a capsule heated on a sand bath 30 parts of rosin is dissolved, to which is added 10 parts of nitrate of uranium for yellow, 30 parts of nitrate of iron for rust color; the mixture is facilitated by adding, drop by drop, 30 to 40 parts of essence of lavender. These liquids, treated like the flux, are thinned down by a further addition of essence and then mixed with the flux in equal or other proportions, according to the tint desired.

The appearance of gold is imitated by mixing the combinations of uranium and of iron with that of bismuth. In this way we produce, after firing, a metallic coloration imitating the different tints of polished gold.

To obtain prismatic colors we take ammoniuret or cyanuret of gold and of mercury, or iodide of gold or tincture of gold. These auriferous compounds are ground on a palette with turpentine so as to form a paste, which is allowed to dry in order to be broken up and reground with lavender. To one part of auriferous product we add one, two or three parts of bismuth flux and spread it with a brush on the ware that is already decorated and fired; the parts are then covered with uranium solution, with the result that we obtain tints that are more or less deep and more or less varied.

All these preparations mix perfectly with one another and can overlay each other, applied with the brush to ware to be decorated they furnish, after firing, brilliant and glazed tints; their variety necessarily increases by applying these lusters on a vigorous ground. Brianchon's productions are remarkable for brilliancy and fire of the colors. They are so bright that they might be taken for underglaze colors. A satisfactory theory, accounting for this process, is yet to be produced, though it may be presumed that the elements forming the rosin have reactions analogous to certain carburets of hydrogen, capable of exchanging one or several molecules of hydrogen for one or several molecules of metal—iron, uranium, silver—to form new compositions, abandoning the oxygen which is irreducible under the action of the fire.

GOLD LUSTERS.

This has all the color of gold and it acquires the metallic brilliancy of gold by simply rubbing it with a rag. It appears probable that the Meissen gold, called light gold, is made in much the same way as that we are about to describe. It has in fact a similar brightness and exhibits a similar want of durability.

The preparation is obtained by precipitating gold from its solution in aqua regia by means of ammonia. We know that the composition which is precipitated is a fulminant, what is known as fulminating gold. As it only possesses this property when it is dry, it must not be allowed to reach that state, but is taken while still wet and mixed with oil of

turpentine, then without adding any flux, it is spread with
a brush upon the glaze of the ware, the same as is done for
colors and is fired in muffle. It adheres to the ware and shows
a bright metallic appearance, which is increased by gently
rubbing it with a rag.

Anyone can see if a piece has had gold laid on by this pro-
cess, as it looks the same on every part of the surface, whether
inside, or outside the ware. The gold exhibits the same
brilliancy, the same polish and does not show in any part
a trace of the burnisher. We can also cover pottery with a
very thin coat of a solution of gold either in aqua regia or
in alkaline sulphides, but it is more difficult, with this method,
to get a coat which is quite equally polished and reflects the
light from every part equally well.

The German methods of preparing this gold are very little
better known now than they were years ago and any one
who wishes to use the best brilliant gold, still buys it from the
German maker. The old Dutertre patents are the basis of the
French preparations, and old as they are they may become
a basis for further research, enabling a substance to be re-
produced, which plays so large a part in the decoration of
porcelain.

We put into a vessel, which is gently heated:

Pure gold	32 grams
Nitric acid	128 "
Hydrochloric acid	128 "

When the metal is dissolved we add:

Metallic tin	0.12 "
Butter of antimony	0.12 "

After all is completely dissolved we dilute the solution with
500 grams of distilled water. In a second vessel we put:

Sulphur	16 grams
Venice turpentine	16 "
Spirits of turpentine	80 "

This is heated until the contents are intimately combined,
after which 50 grams of essence of lavender is added. In this
way we make a true balsam of sulphurized turpentine.

We now pour the solution of gold from the first vessel into
the one containing the turpentine and apply heat, at the same
time we beat the mixture until the gold has incorporated with
the oils. The water charged with acids, separated from the
gold, is then poured off, the mixture is washed with warm

water until the last trace of acid disappears, it is then dried and 65 grams of essence of lavender and 100 grams of common turpentine added; the whole is heated until complete mixture. The clear portion is allowed to stand for a while in a separate vessel with 5 grams of bismuth flux. It is gently heated to bring it to the right consistence.

The liquor then presents itself in the form of a viscid and odorous liquid, giving greenish reflections; the gold is present in a state of solution, after the liquid has been left standing long enough for all the particles of undissolved matter to precipitate in a crystalline form and settle to the bottom; the liquid is separated from these dregs by decantation.

The Venice turpentine gives to the liquor the drying property which it must possess in order that the work should dry promptly. The auriferous resins decompose, at a low temperature, without melting, into a deposit of carbon charged with gold, this carbon burns off and leaves the metal in the form of a laminated pellicle of exceeding thinness. The beauty of the gilding results, among other things, from the absence of all fusion during the destruction of the auriferous matter.

This is a theory I suggested a very long time ago and I have not yet seen reason to change it.

The process used by Carré differs somewhat from the above; 10 grams weight of laminated gold is treated in a matrass with 100 grams of aqua regia, when dissolved the solution is diluted with 150 grams of plain water to which 100 grams of rectified ether is added. The liquid is well shaken to make the ether lay hold of the gold. The liquid is then poured into a glass jar and allowed to stand for a moment, the ether charged with gold will float on top, it is drawn off by means of a stop-cock in the bottom of the jar. The ether is yellow in color.

In another matrass a solution of 20 grains of potassium sulphide is made, this is decomposed by means of 200 grams of nitric acid. The precipitate is first washed until the water comes off quite pure, then it is dissolved in 5 grams of nut oil and 25 grams of common turpentine; in this way a sulphurized balsam is formed to which 25 grams of essence of lavender is added. This solution is poured into the ether solution, shaken up for a few minutes and the whole is decanted into a porcelain bowl; the solution is concentrated to a sirupy consistence and we then add:

Sub-nitrate of bismuth .... 15 decigrams

Borate of lead .... 15 "

The quantity of flux varies, however, with the nature of the pottery which we want to guild. To use it, we spread the oily material in a thin coat, first thinning it with a mixture of equal parts of turpentine and essence of lavender.

It will be seen that in this process, neither tin nor butter of antimony is used.

It is objected to both these methods that they only give us an oily liquid, which does not retain the gold in a state of solution, or suspension, for long; after a time it crystallizes and separates. The gold which comes from Germany is better; it keeps well and gilds well. That which is on the market contains from 14 to 15 per cent of metallic gold, while that prepared by the French method does not contain more than from 9 to 10 per cent of the metal; it becomes poorer in use and finally does not give a brilliant gilding, but only a gold luster, which, at last, is no better than Burgos luster.

I think that the intervention of the balsam has the effect of producing a certain kind of oil in which the essence of turpentine loses a little of its hydrogen; the new composition is apt to combine with the gold to form a complex molecule, in which the gold is dissolved in a particular condition.

The Germans, perhaps, possess the secret of some other essence than lavender, which dissolves the oily composition without reacting upon the gold and without precipitating it. Whatever it may be the gold prepared by them has a notably different odor to the similar compositions prepared in France. This question merits a new examination. I believe that certain of the natural sulphurized oils and the mercaptans among the artificial compounds, may furnish the key to a practical solution. Some attempts which I have made in this direction make me believe in the possibility of a success.

Mercaptan, as we know, is nothing else than a sulpho-hydrate of ethyl sulphide. Other analogous compounds, probably, possess similar properties.

ENGLISH FORMULA FOR LIQUID GOLD.

The translator of Brongniart's works considers it of sufficient interest to insert here a formula, taken from a book of recipes published in England in 1896. It is evidently noth-

ing but Dutertre's method, which was published six decades ago, but it is stated differently.

"Take an evaporating dish, put into it 2 oz. of pure gold, then 10 oz. of hydrochloric acid and 8 oz. of nitric acid, place over a flame of gas until the gold is dissolved and then add to it 22 grains of pure tin; when the tin is dissolved add 42 grains of butter of antimony. Let all remain over the gas until the mixture begins to thicken. Now put into a glass and test with the hydrometer, it should give about 1,800 specific gravity. Pour into a large glass and fill up with water until the hydrometer shows 1,090; pour all the solution into a chemical pot and add to it 4 oz. balsam of sulphur, stirring well all the while and put it over the gas again, in an hour it should give, on testing, 125° Fah.; gradually increase the heat up to 185°, when it should be well stirred, then left to cool about 12 hours. Now pour into a large vessel the watery fluid and wash the dark-looking mass five or six times with hot water; save each lot of water, as it contains some portion of gold. Take away all moisture from the dark mass by rolling on a slab and warming before the fire occasionally so as to keep it soft; when quite dry take two and a quarter its weight of turpentine and add to it and put it over a small flame for about two hours, then slightly increase the heat for another hour and a half; allow it to stand for about 24 hours and then take a glazed bowl and spread over the bottom of it 4 oz. of finely powdered bismuth, pour over it, in several places, the prepared gold; now take a vessel containing water and place the other vessel containing gold in it and heat so as to cause the water to boil for three hours; allow it to remain until settled and pour off the gold from the settlings of the bismuth and try it, if not quite right continue the last process with bismuth until good. The bismuth causes the gold to adhere.

To prepare the balsam of sulphur take:

Oil of turpentine	16 oz.
Spirits of turpentine	2½ "
Flour of sulphur	8 "

Place all in a chemical pot and heat until it boils, continue the boiling until no sulphur can be seen in it; now remove from the heat and thin it with turpentine until about the thickness of treacle, then warm it again, stirring well; allow

it to cool until it reaches 45° Fah., then test it with the hydrometer and if specific gravity is not 995 continue the addition of turpentine and warming until correct, let it thoroughly cool, then bottle, keeping it air tight.

To purify the bismuth take:

Bismuth meal .... 6 oz.
Saltpetre ....¾ "

Melt together in a biscuit cup, pour out onto a slab and take away all dirt, then grind into a fine powder.

TO RECOVER THE GOLD FROM THE REMAINS OF THE FOREGOING PROCESS.

"Put all the 'watery' solutions into a large vessel and mix with a filtered saturated solution of copperas, this will cause a precipitate of pure metallic gold to gradually subside, wash it with cold water and dry in an evaporating dish.

"All rags and settlings that are thick should be burned in a crucible until a yellow mass is seen, then take this and dissolve it in two parts of hydrochloric acid and one part nitric acid, let it remain in a porcelain dish until it begins to thicken and crystals form on the sides, add little nitric acid and heat until crystals form again. Now take this and mix with cold water, add a solution of copperas to it and allow it to settle; pour off the water and with fresh water wash until quite free from acid, the gold may then be used again and, if great care is exercised, almost one-half the original quantity may be recovered.

"The quantities given in the recipe should make about 13 to 15 oz. of the liquid gold.

"It should be fired at rose color heat and does not require any burnishing. If desired it can be fluxed with Venice turpentine, oil of lavender, or almonds."

PLATINUM LUSTER.

We take a concentrated solution of platinum and mix essence of lavender with it, or any other essential oil, without adding any flux. This solution is spread upon the glaze of the ware to which we wish to give the metallic luster of silver, or rather of platinum. The piece is thereupon fired.

Platinum exhibits the full brilliancy of the metal. It spreads evenly over the surface, the color of which it entirely conceals and possesses a polish as lively and as brilliant as if it had been burnished.

BURGOS LUSTER.

This is a pink chatoyant and, at the same time, yellowish-metallic luster, similar to that of several kinds of natural shells; it is not opaque, the glaze upon which it is placed, is distinctly seen, consequently it participates in the color of the glaze and takes very varying and remarkable tints.

There are several ways of making this; sometimes we melt together sulphur, gold and potash, or we may melt the gold in an alkaline sulphide, which is already made; the whole is dissolved in water and precipitated with a weak acid; the precipitate is collected and preserved as a thick syrup, in essence of lavender.

When it has to be used on hard porcelain it is rubbed up with a small quantity of flux; it is spread on the surface of the glazed ware with great care, laying it on as cleanly and as thinly as possible; it is then fired in a muffle, to increase the effect we lay on a second coat.

The action of the fire alone is sufficient, without any rubbing afterwards, to give it its characteristic polish and brilliancy, but the least moisture in the muffle, the least dust, or if laid on too thickly, will spoil it, will make it dull and dirty and take away all its merit.

It is also produced with fulminating gold, but laid on extremely thinly, for if put on thickly it will simply give the luster of gold.

Burgos luster can be placed on any kind of pottery, provided it has a cover or glaze.

This luster often shows circular spots, the circumference of which shine with the metallic brightness of pure gold. It is by means of a very simple expedient that we are able to produce these. It is only necessary, while the ground is spread out and is still in a viscid state, to distribute a few drops of essence over it; these drops spread themselves out, carrying with them the luster, which they accumulate on their circumferences. There the thickness of the luster becomes more considerable, does not give any chatoyant, but the sheen of the gold in all its brilliancy.

The brightness of these little discs is increased by rubbing them with a cloth.

COPPER LUSTER.

This luster shows the same rose colored chatoyant and metallic yellow as the preceding luster. It is perhaps, rather more purple, but its composition is altogether different.

The common Spanish earthenware, of Manassez near Valencia, offers remarkable examples of these lusters, of which the eclat and richness give way in no degree to those obtained from gold itself.

The nature of these lusters was not known with any certainty until Mr. Laurent submitted them to a number of tests and proved conclusively the absence of gold, while several of the reactions which he obtained proved the presence of copper. We continued these researches and have been so fortunate as to determine, beyond a doubt, their true nature.

If we boil the luster in concentrated acid, even in aqua regia, no change takes place, but it is altogether different if, instead of acids, we use caustic potash and in a state of fusion. In this case all the purple color disappears and, if the action of the alkali is not prolonged for more than a few minutes, the color is dissolved, leaving the white glaze of the earthenware upon which it is applied, unaltered. If the potash is then redissolved in water, saturated with hydrochloric acid, it precipitates, with sulphuretted hydrogen, a black substance, which shows all the reactions of copper sulphide.

It is this reaction which removed all uncertainty in regard to this. We had certainly found copper in the glaze that was removed from the body of the ware, on melting it with carbonate of soda and dissolving the result of the fusion in hydrochloric acid, though this copper which we found might come, wholly or in part, from the minium that is an essential part of the glaze.

In what condition is the copper in the luster? how has it been brought to this condition? are the questions that are not very easy to answer. The coloring surface is so thin that it is impossible to seek for the presence of oxygen. It seems probable that it is composed of an inappreciable pellicle of silicate of protoxide of copper; the color of this composition on the one part, its reactions in presence of acids and alkalies on the other, corroborate this opinion.

If this is not so then how are we to suppose that the copper is found in the metallic state when it resists the action cf strong and even boiling acids, without at least admitting that it is covered with a thin coat of glaze which protects it like a varnish? We cannot suppose that the metal can be in the state of a free oxide at the melting point of copper in the presence of a very siliceous body.

We do not possess positive data as to the manner in which this luster is made. Our own attempts to reproduce it, though very imperfect in their method and in their results, have, nevertheless, left us the conviction that we were not far from the method used at Valencia. We placed some sherds of common earthenware in a small muffle and after they were brought to a red heat, we introduced, through a small opening made for that purpose, some coarse paper containing oxide of copper; we then immediately closed the kiln, carefully luted all the openings and left it to cool.

CANTHARIDIN LUSTER.

This, notwithstanding its varied and brilliant metallic coloring is very little used because it is so difficult to lay on and to make a success of it.

It is generally chloride of silver, partly decomposed by vapors of combustion, that takes these colors, under the influence of the vapors. To obtain it we make a mixture of a vitrifiable and a plumbiferous glaze, of a little oxide of bismuth and of chloride of silver. This mixture is put onto the ware with the brush; either making a ground of it or designing ornaments. The piece is then fired in a muffle to a red heat and while it is still red it is taken out of the muffle and exposed to the smoke of some vegetable or animal combustible, or else this smoke is introduced to the muffle. The portions covered with the luster take green, reddish, yellowish, bluish, in fact all the rainbow colors which chloride of silver and lead are capable of acquiring under the influence of the gases.

We can understand what a variety of effects may be obtained by varying the color of the glaze of the pottery upon which we apply the cantharidin luster.

It will be seen that the great difficulty in employing this luster results from the operation of smoking the piece while in an incandescent state and the risk we run of breaking it by

the too sudden change of temperature to which it has to be exposed.

LITHARGE LUSTER.

We are not very certain as to the way in which this singular luster is made; we have only seen it on the very coarsest pottery coming from Germany and the East. It is a yellowish luster, with a golden metallic sheen, greenish, bluish, even with something of the cantharidin luster, but with yellow predominating.

It is, probably, a glaze highly charged with oxide of lead, to which the colors have been given by smoking. Lead often contains some silver, which it would not pay to extract and the presence of this metal may influence the results attributed to the lead, which was regarded as pure. The resemblance in color and tints of the litharge to the cantharidin luster seems to confirm this hypothesis.

These lusters, like everything showy and cheap, were at one time very much the fashion and when, through the ease with which they could be produced, the market was flooded by them the demand for them ceased. They have fallen into oblivion the more readily as it was found that they did not keep their bright appearance long, but they soon became dead and the lusters easily rubbed off.

PREPARATION AND APPLICATION OF THE COLORS—THEIR ME-CHANICAL PREPARATION—TRITURATING THE COLORS.

After a color is made in the way we have indicated, there is still something more to be done to it before it can be placed in the hands of the artist, it has to be subjected to a final operation, which requires considerable care, without which the best color may be spoiled; for, as has been shown, many of the colors are composed of vitreous matters which are of the right hardness and which must be protected from the introduction of any other coloring matter, either hardening or fluxing.

The trituration, which precedes the grinding, is done in a mortar of biscuit porcelain, which must be kept very clean; it is even a good plan to have several of these, as to triturate the delicate colors in different mortars. We can also use an agate mortar, which would be still better. We commence by crushing the material with our pestle, laying a cloth over the

mortar to catch pieces that fly out, then the fragments thus formed are crushed against the sides of the mortar.

GRINDING THE COLORS.

The color thus triturated is then reduced to a state of impalpable powder by grinding.

To grind the colors well is always important, in regard to the preservation of the color, of the desired fusibility of the color and of its greater or less tenuity. It will be of the greatest importance in that which we will call artistic paint-

ing. The success of a work of art may depend upon the great and equal fineness of all the colors and of their purity; in consequence the most certain means of attaining these conditions should be employed, no matter what the expense. The success of a high priced work of art will repay the outlay. In common decorations of commercial porcelain, these considerations though not so important, are not to be altogether neglected, but as the time demanded by these, determines to a great extent the price of the color, it has been sought to cheapen the processes by mechanical means; mills have therefore been constructed, suitable for crushing a quantity of color at one time.
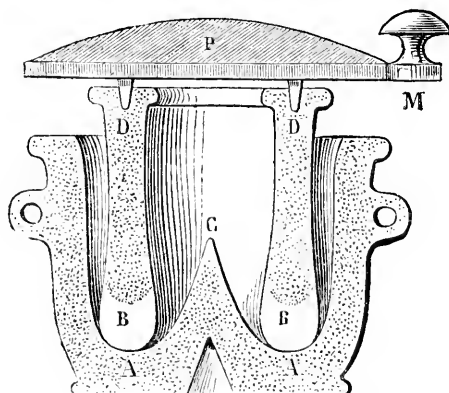
These mills may be made of various substances, but however hard they may be they will wear out and the very fine particles which are detached and mix with the colors, modify their

fusibility. Biscuit porcelain, hard glass and the soft glass called crystal are the materials employed; the two latter sub stances are those which approached nearest in their composition to that of the vitrifiable colors and if some particles from them enter into the pulverized colors the defects which they may cause are very much less noticeable. Crystal may soften the color more than a hard glass will harden it, so that the latter, it seems to us, will be preferable as we can now make glass almost as hard as porcelain.

At Sévres they have made porcelain mills, of the shape here shown, which have, in practice, proved quite satisfactory.

A. is a cylindrical vase, which receives the muller and the substances to be ground; the center of the bottom has a round or conical projection C., forming, with the bottom of the vessel, a wide furrow in which the mill or muller runs. The mill DB. is a porcelain cylinder that works in the vase and is a little higher than the sides of the vase. A. represents the bottom of the furrow, where the color is ground. The upper part of the mill is flat and has attached to it a disc of lead P. or any other metal which will increase its weight; to this disc a handle is fixed to turn the mill.

M. Honore constructed a mill on the same principles, but he has preferred glass to porcelain, considering it better to soften his colors than to run the risk of hardening them. The bottom is flat and is of glass, the muller is of bottle glass and grooved like a millstone for grinding hard substances. By the use of this mill there is an economy of seven-eighths of the time over grinding with a muller and slab.

To use this mill we put the color in the bottom part, wet the color with water and then start the mill. This method of grinding always possesses the advantage over the muller and slab, of working up a larger quantity of material at once, but it does not reduce it to a sufficiently fine powder for colors intended for fine art decoration. For these colors we commence the grinding in the mill and finish it on the slab.

The slabs that are used for grinding on should be square glass plates, sufficiently thick and without any bubbles, perfectly flat and having a ground surface, they must be kept very clean and a separate slab should be kept for each delicate color, if we have not enough slabs to do this then the glass must be cleaned with fine sand or feldspar, until the powder of the substance used for cleaning remains perfectly white.

The mullers used for crushing the material on the glass should be of hard glass or porcelain. They often chip at the edges, any such chips should be removed, as by mixing with the colors they alter their fusibility.

While the wet color is being ground upon the glass slab it is necessary, in order to bring every portion of it under the muller, to continually gather the color to the center of the slab, for this purpose we use a palette knife, but we have to bear in mind the nature of this and be sober in its use or we shall alter the color. Steel knives seem to us preferable, if they are not used more than is necessary; they are hard and they do not give up much to the color, except traces of oxide of iron, which is but a slight inconvenience, even for light colors, such as pale yellows, which already contain a certain proportion of iron oxide in their composition.

The knives of horn and ivory, generally preferred by artists, seem to us much more dangerous. They wear down quicker than steel knives and the large quantity of phosphate of lime contained in them hardens the colors and may prevent them taking a brilliant glaze.

These are the means and precautions to be employed to obtain a good color ready for use for art decorating; they are not all indispensable in the decorating of ordinary or coarse pottery, nevertheless it is always a great advantage to observe them.

There are plenty of other materials and other kinds of apparatus suitable for grinding all sorts of colors well and quickly, but we are only speaking here of vitrifiable colors intended for painting on fine ware and porcelain and these necessitate the precautions which there is no need to take for colors intended for use with larger objects on a manufacturing scale, such as large vases for decorative purposes, floor and wall tiles and similar ware.

APPLICATION OF THE COLORS AND METALS.

The color, reduced to a powder of extreme tenuity, by the mechanical means we have indicated, is ready to be applied to the ware that is to be decorated. We must mix it with something that will enable us to use it easily and that will give it a certain amount of adhesion to the piece, or we cover this piece with a viscid coating that will hold the color, when it is dusted over the surface.

MEDIUMS.

The substances to which the name mediums is applied, should satisfy the following conditions, which somewhat limits our choice.

Water would, probably, be of all materials that which we would prefer; at the heat at which the colors are fired it disappears without leaving a residue and if we reach this temperature carefully the water goes off entirely, without doing any damage, but when the color is dry the pigment does not contract the slightest adhesion to the piece upon which it has been applied and the tints are liable to fall together; then, too, retouching, if not impossible, becomes very difficult.

The first of these defects is easily remedied by adding a little gum or sugar to the water. This medium has been employed for a long while for painting on tender porcelain, the glaze of which always contains lead, but we cannot use gum for colors when the nux has much borax in it. Nevertheless it has been found that the colored fillets, either green or blue, that could only be made slowly or imperfectly with essence, could be executed much better and quicker when worked with gum water. As for the second inconvenience, that respecting the retouching, we have not been able to entirely overcome this in any way and in consequence of this, gum or sugar water is now in nearly every case, abandoned, and spirits of turpentine, mixed with a little thick turpentine, is used instead.

Any kind of turpentine cannot be used. It is an indispensable condition that it should be distilled twice so as to be entirely freed from every trace of rosin. The rosin, not being volatile will form a deposit of carbon at a red heat, which may reduce some of the oxide of lead, that enters into the composition of the flux, to the metallic state.

The thick turpentine which we add to the distilled essence must be properly prepared; this is done by simply exposing the distilled turpentine to the air, in shallow vessels, for several days. In this way we get a good fat turpentine, which will completely dissolve in the essence, in whatever proportions we mix them experience has proved that it will not dissolve well except in an essence that is chemically identical with the source from which it comes itself, so that the best course is to take the spirit of turpentine and transform this into fat turpentine.

In whatever this fat essence is prepared, we should only use just so much as is necessary; the fat essence of lavender should be entirely rejected, as it produces too much carbon, which will take away the oxygen from the lead of the flux and destroy the brightness of the color. This defect, for the purpose we are now considering, becomes a precious quality in the application of metallic lusters; the excess of carbon, either reduces the metals, or it opposes their oxidation during the fusion of the flux that makes them adhere. If the fat oil of lavender is to be rejected for the application of vitrifiable colors it is not the same thing with the essential oil, which, under several circumstances, renders great service; it is less volatile than spirit of turpentine, and when mixed with it it will keep this liquid for a longer time. For extensive grounds, which occupy wide zones on large vases and which should be spread out well and evenly, we have to take care that the part done first is not dry before the end is joined up to it. The dusting bag, which is used to spread the powder color over in the most even manner, will not have any effect on the part that is dry; we prevent the too rapid drying by adding essential oil of lavender to the spirit of turpentine.

Virgin olive oil has sometimes been used for painting on porcelain and it is always employed for painting on enamel. When it is fresh it has but one disadvantage, it remains liquid up to the moment of firing. Nut oils and poppy oils are good when they are fresh, they dry spontaneously in a few days, but when they are rancid they lift up and shift the colors.

MORDANTS.

What French artists call mordants and in English is known as tacky, is a sticky substance used in decorating for the purpose of holding the powdered color laid on by dusting.

These mordants were formerly very much more difficult to compound and were very complicated; several bitumens were put in and garlic and they were boiled with litharge. They are very much simplified now, but for all that their preparation requires great aptitude and above all a special tact, in order to attain exactly the right degree of viscosity.

Linseed oil is mostly used for dusting-on grounds, but nut oil is preferable. It is heated until it becomes sticky; we always add a little litharge, when boiling it, to give it drying

properties. It is laid on the piece to be decorated, with a brush, as we will describe further on.

The use of garlic or onion, to give the mordants a stronger viscosity, is a very ancient process, which, perhaps, ought not to be rejected without a trial. We therefore give the composition of two of the most esteemed of the old mordants, the first was known at Sèvres, about 1750 as Brother Hippolyte's mordant for gold. It was verified by Hellot and entered by him in the register.

Five pieces of garlic and as much of white onion were chopped finely and digested, boiled for eight hours and reduced to a syrupy state in about a quart of white vinegar.

The second mordant, also intended for gold and above all for use on a ground of tender porcelain, has an entirely different composition. In equal parts of essence of turpentine and of fat oil, asphalt, of the kind called "mummy" is boiled, the quantity of asphalt is one eighth in weight of the liquid; during the time of boiling a piece of linen, containing twice the weight of litharge is suspended. After the boiling the mordant is complete.

LAYING ON, EMPLOYMENT AND POSITION OF THE COLORS ON POTTERY.

Vitrifiable colors and the finely divided metals with which we decorate pottery are difficult to use. They are what is called in the workshop "short" and "hard;" we have, therefore, been compelled to seek for every means to employ them more easily and with success.

The way in which we place, lay on, and use the vitrifiable colors on pottery, demands careful consideration upon a number of important points.

The colors, prepared either chemically or mechanically, as we have described in the preceding pages, must be capable of adhering to the ware, either the dead surface of the biscuit or the bright surface of the glaze, before they are finally fixed by the fire which vitrifies them. To accomplish this it is necessary that the color should be mixed with either a simply watery liquid when it has to be put on the matt surface of the biscuit, or, if it is to be applied upon the bright, smooth surface of the glaze, the color must be mixed with a viscid material, whether this be first spread out over the glaze in order to retain the powdered color when dusted on, or mixed

with the color before applying with a brush. In the first case
we call the viscid liquid a mordant, in the second a medium.

VARIOUS METHODS OF LAYING ON COLORS.

To accomplish the desired end the processes used for laying
on colors are very varied, according to the nature of the color
and the position it should occupy in relation to the body of
the ware or the glaze. These processes are, by hand, with the
pencil, with the stippler, with a mordant; there are, too, the
special means of introducing color into the paste or body of
the ware; where it is applied upon the biscuit and, conse-
quently, becomes an underglaze color; introduction of the color
into the glaze itself; application upon the glaze, or china paint-
ing properly so-called; finally the method by reserves and
mechanical printing and dusting on. We will consider these
different processes in their regular order.

LAYING ON AND USE WITH THE PENCIL.

In the greater number of cases the colors and metals are
applied upon ware which is already fired and glazed. It is easy
to understand that the color will not readily adhere to so
smooth a surface; this surface can be made somewhat adhesive
by giving it a thin coat of essence, which will cause a crayon
mark to adhere to it. As has been explained, the colors must
be reduced to the greatest state of fineness by grinding and
they must be made viscid by the addition of fat oil, which holds
the vitreous and heavy colors in place.

The color thus prepared is applied with a pencil having long
hairs. The choice of pencils is a question for the artist; we
cannot say anything very definite on this subject.

We must avoid going over a color again until it has, by dry-
ing, acquired a sufficient adhesion to the surface of the ware.

STIPPLING.

When, instead of ornamenting pottery with paintings, it is
desired to give a uniform color to a considerable surface of the
piece, the color must be laid on as evenly as possible; this
cannot be done simply by means of a pencil, every touch would
show and it would be with the greatest difficulty that we
could get an even ground. After mixing the color with
essence and fat oil in suitable proportions—it is well to let the

color stand in a warm place for a time to get still fatter, or thicker—we lay it on the ware by means of an ordinary pencil, as evenly as possible, we then take another pencil, very much larger than the first and having the hairs terminating in a plane at a right angle to the handle. This pencil is called a stippler. By dabbing over the color, laid onto the ware, with this species of brush, we get the color of an equal thickness all over and cause the streaks and spots to disappear, which result from laying on with the pencil. This operation is called stippling.

Stipplers may be of various sizes; there are small, medium and large sized. The small ones are used in art decoration to equalize a rather large tint, such as a sky, or to blend one tint into another. The large sized stipplers are used for laying on grounds.

In the application by this means it is necessary to have the color thicker than for painting, or laying on with the pencil. It is indispensable that the join between the commencement and the finish of a band of color shall be made easily, so as not to show a difference.

In order to have a fine and even ground, we must nearly always lay it on in two coats. In addition to this the color must not contain any moisture, otherwise it will run together in tears; we should also avoid dust, as much as possible; little particles of dust draw the color to themselves, producing thicker places which make spots and which are also very liable to scale off. It is found that colors put on in this way are not quite so bright as the others.

LAYING ON WITH A MORDANT.

There are certain colors which, in order to produce their effect, have to be laid on rather thickly or, in consequence of their vitreous nature, they cannot be spread evenly with the stippler. These colors are laid on by means of a mordant. The color, in this case, does not need to be ground so finely as for painting with the pencil; it must, however, be perfectly dry.

The portion of the ware to which the color is to be applied has a thin coat of "tacky" or mordant given to it; this, as stated before, is a fat oil rendered viscid by boiling with litharge. This oil is laid on with a pencil or a stippler and as it has a color of its own it is easy to spread it evenly.

After the piece, or portion of the piece, that is to receive the color is coated with the mordant, we take the powdered and thoroughly dried color, put it in a sieve, the silk mesh being of the required fineness and sift the color over the ware. The color will only attach itself to those parts that are coated with the mordant. We then clean off any dust from the color that may be on the other portions. This method is employed principally for laying on grounds for sharp-fire colors.

POSITION OF THE COLORS AND SPECIAL METHODS OF APPLYING THEM.

In the preceding article we described the different means of laying on colors, without any reference to the colors themselves, or to their positions on the body of the ware. These positions have, nevertheless, a considerable influence not only upon the color, but also upon the way in which it is applied.

We can introduce the color into the paste of the body itself, or it can be put on the green ware, or upon the ware when it is partly or fully burned. The color may be mixed with the glaze, or laid on the glaze, or it may be desired to have the color in certain parts only, leaving the remainder of the surface without any color. The various methods employed to obtain these results, we will now proceed to examine.

COLOR IN THE PASTE OR BODY OF THE WARE.

All color introduced in the clay forming the body of the ware becomes more developed and more lively in proportion as we approach to vitrifaction, but the coloring oxides make the clay more fusible and this means of coloring is thereby reduced when the paste is intended to be fired at a high temperature. Therefore among all the pastes the one which admits of the least variety in coloring is hard porcelain. Its coloration, which is very fine and regular, is almost entirely confined to pale blue; this is done with cobalt, an oxide which has a high coloring property even in very small quantities and only slightly changes the composition of the paste. We have succeeded in obtaining porcelain pastes with considerable varieties of color; these were, a fairly deep blue, green, bluish-green; black, pale yellow and several shades of pink. The coloring oxides used were, chrome, cobalt, iron and manganese, titanium, and purple of Cassius. But by these means we get near to the composition of stoneware paste, of earthenware

and of tender porcelain. This latter ware is the one the paste of which is capable of taking nearly all the colors and exhibit them with the more vivacity and purity in proportion as their composition is of a vitreous nature. Thus tender porcelain, which contains the elements of glass and fine English faience, that considerably resembles it in composition, are the kinds of pottery that offer the greatest variety of and the most vivid colors.

Since the publication of the second edition of Brongniart's work, containing the preceding lines, the manufacture of colored porcelain paste has made considerable progress. The general principles stated by Brongniart are an exact expression of the greater portion of the facts, but they have to be modified in part through the introduction of new coloring materials, of new oxides, or of new mineral matters. The few observations devoted to this matter, though so interesting, were certainly not enough for the consideration of all the colors that can be introduced into the clay for underglaze.

Although it was recognized that to color porcelain pastes it was only necessary to modify their composition and that the lower the temperature at which the paste was burned the easier it was to color, the attempts to do this were confined to the addition of some color elements to the white paste, in order to get a particular tint.

I cannot, in the space at my disposal, give a full exemplification of all the processes for this purpose and must confine myself, on this subject, to stating as concisely as possible the principles which serve as a basis for the work of today. Up to the present time the irregularities that have been noted in the colored pastes have been due to the conditions of the atmosphere in which they have been burned. A real progress was accomplished by the studies which resulted in the conditions being clearly defined of a reducing, an oxidizing, or a neutral fire, suitable for any particular oxide or coloring matter. This was a great service rendered to the art by the royal works at Sévres in calling the attention of manufacturers to the point.

COLORING MATTERS.

Blue.—Before the year 1848 no other blue pastes were known than deep blue, agate blue and a bluish gray called chalcedony blue. The first was made by means of a sharp-fire blue, the

others were obtained by the addition of pure oxide of cobalt to the white paste. After this I prepared, for the first time, a much brighter blue by fritting the sharp-fire blue with an equal weight of flowers of zinc for six hours, in a porcelain biscuit kiln. This blue is now known as Persian blue and has become the base of a number of other colors, the tints of which have been modified by oxide of chrome, oxide of uranium, pitch-blende and artificial and native chrome iron. The sharp-fire colors in which oxide of zinc is present, can only be burned in an oxidizing fire, otherwise we run the risk of the oxide being reduced and volatilized. In a reducing fire the color takes a violet shade.

Gray.—Platinum is capable of giving a very superior gray color to pastes for burning in a sharp fire and competes in this respect with sequioxide of iridium. These colors are of great value in the sharp fire for regular and constant grounds. They will stand the hard fire of the porcelain kiln.

Yellow.—Oxide of uranium in small quantities, five parts at most to 95 parts of paste; burned in a hard fire and an oxidizing atmosphere, that is to say, with a current of air going during the whole time of burning, produces a fine, pale yellow, with an inclination to greenish. In a neutral atmosphere it tends to a pale gray-green. In a reducing atmosphere the body is more gray.

By increasing the doses of oxide of uranium, or of pitch-blende when it is pure, we obtain fine reddish, chocolate, brown and black tones, if burned in an atmosphere charged with reducing gases.

Browns.—Oxide of iron combined, under the influence of heat, with oxide of chrome, has been used for a long time in the preparation of pale and deep browns. I prefer to use native chrome iron, but regard must be had to the exact composition of the ore, which appears to admit of considerable variation; in consequence of this some very serious variations are possible when using different samples, which are experienced, either in the colors obtained, the fusibility given to the paste, or the reactions that may occur with the gases in which they are burned.

Rose.—The classical researches of Ebelmen upon the crystallization of spinel ruby and corundum are well known and it occurred to me to use the aluminates of chromium and among others the artificial ruby crystals for coloring porcelain pastes.

I soon found that there was no need for the aluminate of chromium to possess the crystalline form in order to resist the solvent action of the paste with which it was incorporated. In consequence of this the preparation was very easy. It sufficed to prepare an aluminate colored rose with chrome and submit this mixture of pure anhydrous alumina and bichromate of potash to the hard fire of a porcelain kiln in a current of air. The anhydrous alumina is obtained from the calcination of crystallized sulphate of alumina. The proportions may be varied from my first attempts and may be made 5, 10 or 15 of bichromate for 100 of calcined alumina. Five per cent gives a pale pink tint, 10 per cent produces a bright pink, sometimes greenish, 15 per cent a decided green, which changes its appearance in artificial light. The most suitable proportion for obtaining a bright pink appears to be seven and a half per cent, but the paste must always be burned in an oxidizing atmosphere, in order to avoid greenish reflections.

The rose-colored oxides are transformed to mauve, lavender, violet, lilac, by adding, along with the bichromate of potash, pure oxide of cobalt.

The introduction of alumina, magnesia and oxide of zinc, has enabled us to form products analogous to the aluminates, which are highly refractory and of great value for colored pastes, particularly when they are melted, or only fritted, with feldspar or pegmatite.

COLORED PASTES.

The composition of colored pastes should be arranged according to fixed principles; it is based upon the mixture with the paste of various oxides in certain proportions. These coloring matters are, in some cases, more fusible than the white paste and, in other cases, less fusible, or if of the same degree of fusibility when alone, they may when added to the paste increase or diminish its fusibility. It is obvious that the degree of fusibility must correspond with the normal temperature of burning, which has been determined beforehand. Let us therefore admit the following principles:

First Principle.—If the coloring matter is more fusible than the paste, we must make the latter less fusible, that is, we must increase the refractoriness of the paste.

Second Principle.—If the coloring matter is more refractory than the paste we must compose a paste that is more fusible.

Third Principle.—In the exceptional case of the coloring matter and the paste being of equal fusibility we only need to mix the two elements in their regular proportions.

It is well not to lose sight of the fact that every porcelain paste is necessarily formed of an infusible plastic element, the kaolin, and a fusible element the pegmatite, feldspar, or feldspathic flinty sand. These data being admitted we have only, in the first case, to increase the proportion of kaolin, in the second, we increase the feldspar, pegmatite or feldspathic sand.

These general principles being agreed upon it must be considered as of prime necessity that the composite paste shall have a uniform shrinkage, both in the biscuit and in the final burning. As instances of this I will confine myself to the two following examples:

A. COMPOSITION OF PERSIAN BLUE PASTE.

Parts.

Material called Persian blue (composition given above.. 500
Washed kaolin (St. Yrieix clay) 2,000

B. ROSE PINK PASTE.

Materials of artificial ruby 640
Containing: Alumina ....800|
                                                            | 860
                    Bichromate of potash .... 60|
White clay from Dreux ....:....... 200
Pegmatite hard porcelain glaze 160

As for the coloring matters whose fusibility does not differ notably from that of the normal paste, it is advisable, or I would say, indispensable, to first find how much of the coloring matter can be mixed with the paste without any objectionable results, such as blisters, tears, cracks, etc. Thus the standard paste used at Sévres cannot take more than 5 per cent of oxide of nickel, above this proportion makes the paste unfit for use, but any quantity less than 5 per cent can be mixed with the paste.

I consider this point of the highest importance and we find in practice that two colored pastes, taken alone, may each possess excellent qualities and yet, when mixed together, be absolutely worthless.

When a paste is not sufficiently vitreous in itself the coloring matter should be put in in the shape of a frit. As the coloring of the pastes of fine faience and fine stoneware is based upon compositions which are very similar, the same formulas will serve for the two. The composition for black bodies has been given elsewhere, as well as that for fine stoneware in gray, pale blue, deep green, pale green, bluish green, pure black and brown, so that we will only give here the compositions not before mentioned, of colored bodies for hard and tender porcelains:

COLORED PASTES FOR HARD PORCELAIN AND FINE STONE-
WARE.

A special paste, A, is prepared by taking—

Flinty kaolin 48
Pure white plastic clay 16
Pure quartzose sand 16
Porcelain glaze 16
Carbonate of lime 4

This is the base for most of the colored pastes that follow.

BLUE PASTE.

Paste A..... .... 89 or 70
Sharp fire blue (preparation previously given) .... 10 or 20
Plastic white clay .... 0 or 10

These plastic white clays remain blue under the porcelain glaze.

PALE BLUE PASTE KNOWN AS AGATE.

Paste A..... 95
Oxide of cobalt 5

DARKER AGATE.

Paste A....... 90
Oxide of cobalt 10

The oxide must be thoroughly well mixed with the paste in the usual way. When glazed the ware has the grayish-blue tint of chalcedony.

GREEN PASTE.

Paste A..... .... 65 or 85
Sharp-fire blue for grounds .... 5 or 10
Chrome oxide .... 10 or 5
These pastes are of a fine green color, which is not changed by glazing.

PALE BLUISH GREEN.

A fine pale bluish-green can be produced by composing a green oxide as follows:

Chrome oxide 50
Carbonate of cobalt 25
Carbonate of zinc 25
To make the paste we take:
Paste A .... 90 or 95
Green oxide .... 10 or 5
These green bodies, when they are not under glaze, have a pale bluish-green tint, but they become a lively and decided green with the covering of glaze on.

GREENISH-BRONZE PASTE.

Paste A... 95
Calcined oxide of nickel 5

BRONZE OR OLIVE-GREEN PASTE.

Paste A....... 88
Calcined oxide of nickel 10
Oxide of cobalt 2
We can vary the proportions of the oxides according to the tint we wish to obtain. Without a glaze this paste is a matt bronze, which can be enriched with touches of gold. When glazed it becomes a rather bright green-bronze. The glaze must not be thick. Depending upon the fire, its temperature and purity, this green-bronze tint is sometimes very fine; at other times it is dull and dirty. It is this uncertainty which has caused the use of this color for porcelain pastes to be discontinued.

BROWN PASTE.

Paste A......... .... 85 or 80
Calcined oxide of iron .... 15 or 20

The whole must be thoroughly well ground together; the paste must be washed with plenty of water and that which remains in suspension must be set on one side; re-grind that which is precipitated and rewash it continually until there is no more precipitate. In this way we get a paste which is extremely fine and which, according to the proportions of iron and of paste, takes upon its surface a tint which varies from reddish-brown to a brown that is almost black and which, according to the temperature and tne nature of the ingredients is liable to swell and even to melt; therefore the above proportions must only be considered as indications, which may have to be modified on trial.

BROWN-BLACK PASTE.

A frit is made composed of:

Chromate of iron 14
Oxide of cobalt 14
Oxide of manganese 14
Paste A........ 58

This is calcined in the hard porcelain fire and is then mixed in various proportions with paste A.

BLACK PASTE.

Paste A........ .... 91.0
Calcined oxide of iron 5.5
Calcined oxide of cobalt 3.5

This paste, sometimes a pure black, is laid on in a not very thick coat, upon an ordinary white body and often stands well without chipping or crazing. It can be used for cameos and white bas reliefs.

Paste A. mixed with oxide of uranium makes a fine black paste.

GRAY PASTE.

Paste A 97.5
Rutile 2.5

This paste preserves its gray color under the glaze.

PALE YELLOW PASTE.

Paste A. 95
Rutile or native oxide of titanium 10

This paste when finely ground shows a beautiful pearl gray, under the glaze.

FLESH TINT PASTE.

Paste A. 90
Rutile 10

This paste does not keep its color unless put under glaze; if enameled it becomes a dirty gray.

PINK AND PALE PURPLE PASTE.

These tints are obtained ·by means of the precipitate of Cassius; we prepare a solution of gold as has been described further back, mix paste A in this solution and stir it well; we then pour in, drop by drop, a solution of tin oxide which precipitates the purple. The chalk must be left out of the paste A until after it is colored and washed, when it is added in suitable proportions. By varying the proportions of purple and of paste we can get a variety of tints which do not change under glaze.

COLORED PASTES FOR ARTIFICIAL TENDER PORCELAINS.

Turquoise Blue.

Make a frit composed of:

Peroxide of copper.......................... 5.88
Anhydrous carbonate of soda...............17.65
White sand 76.47

It must be noted that if the frit is made at a very high temperature we must increase the quantity of oxide of copper, because of its great volatility. We then take:

The above frit, ground.....................59.26
White frit for porcelain....................14.81
Washed marl ....;.11.12
Chalk 14.81

We make an intimate mixture of these materials by crushing them together. The introduction of organic matter into this paste should be avoided. The paste should not be fired at a higher temperature than an oxidizing fire.

Pale Green Paste.

Ordinary white paste.........................90
Chromate of lead............................ 5
White sand 5

Grind this well together. The sand only serves to harden the paste, which the lead salt renders very fusible. The proportion of sand may be augmented, if necessary.

There is no doubt that the chromic acid is brought to the state of a very finely divided chrome oxide. Triboullet has strong reasons for believing that it is this state of extreme subdivision which gives richness to the tint.

Blue Paste.

In the composition of ordinary white frit we put one to four per cent of oxide of cobalt; this is fritted, and with this frit we mix marl and chalk in the same proportions as for the ordinary white paste.

There must be a current of air in the kilns where this paste is fired.

Violet Paste.

Oxide, or carbonate, of magnesia (pure)......	5.55
Anhydrous carbonate of soda...............	16.65
Nitrate of potash..........................	5.55
White sand	72.25

Frit these together. (We can also produce very fine tones by mixing a small quantity of oxide of cobalt with this.)

Frit according to above formula............	76.92
Chalk	11.54
Marl	11.54

The elements of this paste mix completely when they are pounded together.

Lemon-Yellow Paste.

Antimoniate of potash.....................	33.34
Minium	50.00
White sand	16.66

Frit together; a high temperature is not needed, and to form the paste mix as follows:

Frit, above described.......................	7.14
White paste for tender porcelain............	85.72
Biscuit for tender porcelain.................	7.14

Mix all thoroughly well together.

Nankin Yellow Paste.

Antimoniate of potash	23.53
Sesqui oxide (red oxide) of iron	11.76
Minium	47.06
White sand	17.65

Frit this at a moderate temperature.

Above frit	7.14
White paste for tender porcelain	85.72
Biscuit of tender porcelain	7.14

This is to be well crushed and the whole well mixed.

Black Paste.

This can be made with violet paste with which sulphur and peroxide of iron are mixed.

A piece often appears to be formed of a colored paste which is not really colored throughout its entire thickness. The mass is a white paste and the colored paste only forms a layer, of two to three millimeters thick, on the exterior surface of the piece. It was in this way that Wedgwood made his reproduction of the famous Portland vase, in black paste with white bas reliefs. It is in this way that, at Sèvres, the white cameo figures, on a ground of blue are produced. The blue itself is applied in a thin layer upon a base of hard white porcelain.

UNDERGLAZE COLORS.

Slip.

We referred to slips in a previous work, but as we considered these as a means of decoration we deferred the description of them to this place; we will therefore present here all that concerns this method of ornamentation.

It is necessary, in order that a color that is put under a ceramic glaze should become glazed and brilliant by the fusion of the cover glaze, that the color should be spread evenly and should not become detached, either during or after firing. The metallic oxides in a pure state very rarely fulfill these conditions, even when, as with porcelain, the ware is fired at a very high temperature. It is, therefore, necessary that all the colors with which we decorate a piece in placing them under the glaze, should have some connection, in their composition and nature, both with the body of the ware and with the glaze which covers the colors. The colors, too, must have sufficient

adhesion, both in themselves and to the body of the ware, so
that they will not be diluted, weakened, or washed off by the
application of the glaze. The special process which is called
slipping (engobage) fairly fulfills all these requirements.

It consists in covering a ceramic paste with an earthy ma-
terial, be it white or colored, which, by its opacity, conceals
and seems to change the color of the paste, to such a degree
that a piece of pottery which has a body (paste) of a reddish
or yellowish color can show on its interior a fine white and on
its exterior an equally fine chestnut brown ground. The glaze
which is placed upon these grounds gives to them the brill-
iancy required.

It is to the earthy, colored material that the name of slip
(French, engobe) is given.   This invention, which reached a
remarkable degree of development in England, had its origin
in Italy, somewhere about 1300, though some Egyptian pot-
tery, covered with a silico-alcaline glaze, shows the application
of a white slip between the yellow body and the turquoise-blue
glaze. The museum of ceremics at Sèvres possesses fragments
of Arab pottery brought by M. Lenormant, attributed to the
eleventh century, the body of which is very dark, covered with
a transparent glaze, that has the appearance of being opaque,
by means of a very white and thin slip, applied direct upon
the body and receiving the glaze.

Some antique pieces of pottery, though without glaze, have
been embellished with slips which have remained matt and
which easily become dirty. Such are the white, yellow and
violet colors of the Greek, the fine white slips of the Athenian
vases and the whitish slips upon reddish-yellow bodies upon
some vases of Roman manufacture.

Slips are essentially composed of an earthy, clayey base,
colored naturally by ochres, or artificially by various oxides.
In the first we do not introduce any vitreous matter; we use
them just as nature gives them to us; all that we do is to wash
them and reduce them to a fine powder.   But in the slips
which are colored by the introduction of various metallic ox-
ides it has been noticed that it is necessary to add an alkali,
to improve the colors and to give better adherence to the ware.
The mixture of alkali, sand and oxide is first fritted together.

We give here examples of the compositions of some of these
slips.

The slips that are entirely earthy, that is, those without a
frit are:

The red, produced by calcined yellow ochre.

The brown, produced by earths of Sienna or Umber, which
owe this color to manganese.

The black, which results from a mixture of calcined and
manganese, 99 parts, and white clay, 1 part.

The white, which results from a mixture of white clay, or
clayey kaolin, 96 parts, and tin oxide, 4 parts.

As for the slips that contain frits, they are composed, in the
first place, of colored vitreous frits, which, after being pulver-
ized, are added to the white clay to form the slip.

Yellow Slip.

A frit is made of:

Sand	25
Carbonate of potash	50
Naples yellow	25

Of this frit one part is taken and two parts of white clay.

Violet Slip.

Frit:

Sand	32
Carbonate of potash	66
Manganese	2

Two parts of this frit is added to two of white clay.

Blue Slip.

Cobalt, azure blue	32
Minium	3
White clay	65

This is not fritted.

Green Slip.

Blue frit	40
Yellow frit	40
White clay	20

Slips are more frequently put upon green ware than upon
biscuit; in the first case they may be simple earths and not
contain any frit, but it seems that in the second case the color-
ing matters should be fritted.

Slips should be very finely ground, then mixed with water
to the consistence of a soup; they easily remain in suspension
in the midst of the clay which sustains them.

The ware to be slipped is allowed to become sufficiently firm to permit of its being handled, and even of being plunged into the slip without there being any risk of damage, but ordinarily we prefer to place the slip on the ware, or in it, if it is the interior that has to be covered. Sometimes the slip is spread over the ware, at others it is blown onto it, projected onto it by insufflation. By this latter process the slip is put into a vase, resembling a teapot, but with the spout straight and contracted (see figure). Then on blowing into the large opening O of this vase the slip is forced out of the spout B, the opening of which can be made smaller by means of a straw that can be adjusted, and in this way the ware is sprayed with slip. The whole or part of the piece can be covered, as desired. In order that the slip should be spread as equally as possible we usually put the piece to be slipped on the lathe and turn it while spraying.
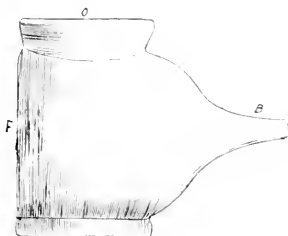
We let the slip harden, which takes place immediately in consequence of the property that articles nearly dry possess of absorbing moisture; we then put the piece back upon the lathe so as to get a sharp edge to the slip, or we can cut away some of the slip, showing a band, or bands, of the color, whatever that may be, of the body. Sometimes the portions that are scraped off are covered with slip of another color and the piece is ornamented in this way by bands and fillets of different widths and colors. Or we may cut designs on the piece, either in the ordinary lathe or the guilloching (engine turning) lathe, producing incised ornamentation; then the surface is covered with a slip, which fills all the hollows, but on putting the piece again in the lathe and, with the knife or chisel, cutting away all the slip until the elevated portions of the ware are reached, the slip will only remain in the incised parts.

These operations finished—and it can be ready understood that an infinite variety of designs and colors are possible—the piece is fired in a biscuit kiln as would be done if no slip were used. We thereupon apply the glaze that is suitable, but which must be a transparent one.

The Chinese have placed extensive ornamentation in white, under the glaze of hard porcelain, which must have been put on by slipping. It is supposed that this was done with a white talc.

The true slips are only applied upon faience, either fine or coarse. This is the principal method of using colors under glaze for this ware, though we may consider as in the same category, first, the blue and chrome-green ornaments that are applied direct upon the biscuit of hard porcelain and on the biscuit of tender porcelain; second, the blue grounds of these porcelains, because the cover in the first case and the crystalline glaze in the second are placed over the colors. Nevertheless we shall consider this placing of the colors as belonging to a process different to slipping, and we will describe this under the classification of applied colors.

COLORS APPLIED UNDER GLAZE.

Under glaze colors are those vitrifiable colors which are under the cover glaze and play the part of a slip.

The slip, properly so called, is an earthy color; the underglaze color is a vitrifiable slip. As a striking and complete example of underglaze color when it is not a slip, but an application of color, we cite the process of application of blue on tender porcelain biscuit beneath a crystalline (flint glass) glaze, which we have given elsewhere, but repeat here. The beautiful Sèvres blue for grounds, which has had, and still possesses, a great reputation, is made as follows:

We take cobalt ore, either Swedish or Saxon, which is a sulphide of cobalt, iron and arsenic; calcine it, to get rid of the sulphur and a portion of the arsenic; it is then dissolved in nitric acid, and we precipitate the arsenate of cobalt by means of carbonate of potash, taking the customary precautions, though it is not necessary to have a perfectly pure oxide, and Hellox believes that it is even advantageous for the development of the color that a certain quantity of arsenate should remain in the oxide of cobalt to be used.

This cobalt, properly dried, is combined by fusion with the following substances:

Arsenate of cobalt.......................... 6
Siliceous sand from Fontainbleau............ 4
Carbonate of potash (pure)................1 to 2
Nitre ....1 to 2

This mixture is melted in a crucible. It sometimes happens that the tint of the blue ingot which is obtained is not quite satisfactory; in such case we remelt it, adding either nitre or crushed silex, according as we find it too hard or too tender.

DECORATION WITH THICK SLIP OR PASTE.

When the vitreous ingot, resulting from the fusion, has the desired tint we reduce it by pounding and grinding it to a powder, which must not be very fine. This is mixed with water and laid on the porcelain biscuited body with a small steel palette, and spread as evenly as possible. It is fixed to the biscuit by firing it in the kiln. The ware comes out with a rough and bubbly surface. This is rubbed smooth with a piece of stoneware. Very often a second coat of blue is put on and again fired. This also has to be smoothed by rubbing. Upon this we place the glaze for tender porcelain, of which more than one coat is sometimes put on.

It is by the preparation of the oxide, of the blue, laying it on of a suitable and equal thickness, the exact temperature which it receives, both the two coats of blue and the two coats of glaze, that we get the beauty, the brilliancy and the velvety character of this color. As it was extremely difficult and, consequently, very rare that all these conditions could be equally fulfilled, it was also rare to have a fine blue ground on tender porcelain, as it is difficult to obtain it, exempt from faults, on hard porcelain.

We can see from this that the tender porcelain of Sèvres,

the manufacture of which was discontinued in 1804, must, in order to have got its beautiful appearance, have gone through the sharp fire four or five times.

This method of decoration in blue underglaze is also that employed by the Chinese, the Saxons and by a number of German factories, and has been imitated in some of the French factories, with slight differences of detail, according to the place and the circumstances.

After making the biscuited body less absorbent, either by covering it with or soaking it in a solution of gum, an albuminous liquid such as milk, or a greasy liquid such as essence, or even by soaking it in water, we are able to apply colors and spread them over the surface, or make ornamental designs upon it. If we have simply moistened the biscuit, we let the color on its surface dry, then dip the piece in the glaze and fire in the gost oven.

If it has been necessary to saturate the biscuit with a material which completely destroys its absorbent property, then we must destroy this material by the application of heat, so as to restore to the biscuit its property of absorbing liquid, thus permitting the glaze to spread over it and attach itself to the body.

The course which is adopted depends upon the nature of the color and particularly of the designs that are to be applied upon the biscuit; thus the burning off is indispensable when printing on the biscuit, as will be seen in the description of this mechanical process. In these cases the color is under the glaze, not in it. The result, as a rule, is that it is more even, but it is often less brilliant, especially that on hard porcelain, because a feldspathic glaze is always slightly bubbly.

COLORS IN THE GLAZE.

In the second process, which is generally the better one notwithstanding the difficulties it presents, we mix the oxide, sometimes pure, sometimes with the addition of a certain proportion of feldspar, in the glaze and in such proportions as to sufficiently color it, but never in such quantity as to cause the glaze to become opaque nor too fusible. This is a condition sometimes more difficult to fulfill than might be supposed. The biscuit is dipped into this colored glaze; this appears sim-

ple enough, but in order to obtain a fine and even ground there are quite a number of things to be considered and, consequently, of precautions to be taken. In the first place it is important that the biscuit should not have been very hard burned so that it should remain very absorbent. Quite frequently the exterior alone of the piece is to be colored. We must then put a clear, or uncolored glaze in the interior. If we desire to keep this off the exterior this is a condition rather difficult to fulfil, we dip the whole piece into the glaze and when it is dry we remove it from the outside by brushing. We let the piece dry completely, then dip it into the colored glaze, taking care that none of this runs inside. We either cork up the mouth of the vase where this can be done, as in pieces with narrow necks, or dip it in, mouth downwards. or else, if the mouth is uppermost, we only dip the piece in so deeply as to let the glaze come up to the edge, just to the point where the two glazes meet.

This dipping demands considerable skill and here we find the second difficulty. As the glaze for the exterior is colored, but is not opaque, we have to spread it over the piece with the greatest possible exactness, otherwise the vase will be of an uneven and undecided tint and will be regarded as a defective piece. Now we will find that on plunging the vase vertically into the colored glaze to prevent any of it running inside, the foot of the vase is in the glaze twice as long as the upper part, or neck, is; we must therefore vary somewhat the times of immersion of these two portions and so arrange that the neck will remain rather longer in the glaze than the foot which is a very difficult thing to do.

We know that on taking a piece out of the tub of glaze, the liquid, which does not adhere well, flows along the piece, what is called the drip, but the extra thickness of this drip, over the glaze which has been flowed evenly on the ware, forms lines, bands or veins that, being thicker, are more strongly colored. It is only by considerable skill and after observing carefully the behavior of this drip in different positions of dripping, that we can avoid these inequalities in thickness. We do not always have a choice in the matter of the positions in which we can dip a piece and when this has an opening in it that cannot be closed, where the colored glaze will run in-

side at the slightest false movement, it can be understood that the precautions to be taken are innumerable.

This method of coloring was, formerly, sufficiently rare; as it was necessary that the color introduced in the glaze should be able to resist a temperature high enough to vitrify the glaze, this condition reduced the number of colors that could be employed, the more so in the case of a glaze that had to be subjected to a higher temperature. This is not the only cause which reduces the number of oxides that can be used; certain coloring oxides either increase or diminish the fusibility of the glazes so as to interfere with the equilibrium of expansion and contraction, or the bond, which should exist between the glaze and the body; such are the oxides of cobalt, iron, manganese, etc.; others diminish the fusibility, rendering the glaze opaque, dull or dead; such are the oxides of tin, chromium titanium; finally the elements of the glaze itself, act more directly upon the oxides and modify them more completely, accordingly as they are in the glaze or upon its surface.

Considerable difficulty has been met with in mixing with the glaze, in an intimate and permanent manner, the metallic oxides which should color it, hence the restricted use of this method of ware, in which the glaze can be durably and cheaply colored on its surface in a muffle fire; but the process with colored glazes is economical and there is yet another advantage for many kinds of ware, as porcelain for instance, by avoiding the re-firing in the sharp fire, necessary to bring up the brilliancy and gloss of the colors that are laid on the glaze we escape the expense and the numerous chances of damage to the ware attendant upon each re-firing. numerous attempts have therefore been made to overcome this difficulty in the use of colored glazes which, as for the hard porcelains, have to be fired with the paste (body) of the ware at a high temperature.

When the color is, like the glaze, spread over the whole surface of the piece, this kind of glaze is called a ground color. It is scarcely used for anything else than enameled faience (earthenware) and the hard and tender porcelains.

The white enamel of white earthenware is composed, essentially, of oxide of tin, oxide of lead a quartzose sand, bay

salt and soda. The oxides of tin and of lead are mixed by their calcination together in a small reverberatory furnace. The combination of these two oxides gives a yellowish powder which, in France, is called calcine, in England putty powder, and which is the base of white enamel. This is made from the mixture of the metallic, siliceous and saline materials at the bottom of the furnace in a place called the basin.

The compositions vary somewhat, according to locality, the material of which the paste is made and the purpose for which the ware is intended. We give here the hardest, No. 1, that is to say, that which contains the largest proportion of tin, and the softest, No. 2, which contains the most lead and is the most extensively used.

No. 1.	No. 2.
Tin and lead calcine, composed of tin oxide 23, lead oxide 77 44	Composed of tin oxide 18, lead oxide 82 47
Minium 2	. . . . —
Sand (Nevers) 44	Sand (Nevers) 47
Bay salt 8	Bay salt 8
Soda (of Alicante) 2	Soda (of Alicante) 3

If we have no Nevers sand, which is rather fusible, we replace it with a pure quartzose sand and increase the proportion of flux as follows:

No. 3.	No. 4.
Calcine of tin oxide 23, lead oxide 77 45	Calcine of tin oxide 18, lead oxide 82 45
Washed quartzose sand . . . 45	Washed quartzose sand 45
Minium 2	. . . . —
Bay salt 5	Bay salt 7
Alicante soda 3	Alicante soda 3

The melted mass is not always white on leaving the basin, it is sometimes even nearly black in consequence of the carbonaceous matter it contains, and which could not get away from it, but when crushed and remelted on the ware it gives the desired white color. The heat required to melt this in the basin has been reckoned at from 60 to 70 degrees on Wedgwoods' pyrometer.

The enamel of earthenware may be colored yellow, pure green, pistachio green, or blue by the following metallic oxides.

YELLOW ENAMEL.

White enamel 91
Naples yellow (oxide of antimony) 9

BLUE ENAMEL.

White enamel 95
Oxide of cobalt in state of azur 5

PURE GREEN ENAMEL.

White enamel 95
Copper scales (protoxide) 5

PISTACHIO GREEN ENAMEL.

White enamel 94
Protoxide of copper 4
Naples yellow 2

VIOLET ENAMEL.

White enamel 96
Peroxide of manganese 4

These colors are sometimes formed by adding in the composition of the enamel itself the coloring oxides, sometimes we merely add these to the crushed enamel.

We must avoid putting ware that is in white enamel in the kiln alongside pieces that are colored green or blue, as these colors are capable, by their volatilization, of giving a tint to the white.

Brown enamel or white, finely powdered and suspended in water in the state of a thin slip, is put on the ware by dipping, when the entire piece is of one color, and partly by dipping and partly by spraying when the piece has to be brown, or colored, outside and white within.

The piece is first dipped into the enamel for the exterior, plunging it in up to its edge; the workman holding it by the inside. The outside enamel is allowed to set; the piece is then taken in hand again and the white enamel for the interior is poured in, either by a ladle or cup and the glaze is distributed over the whole interior surface by a suitable movement; the excess is poured back into the tub.

The ware, when enameled of a suitable thickness,will usually require to be retouched in places where the enamel is wanting; it is necessary to remove the enamel on the foot of the piece to prevent it sticking to whatever it stands upon when being fired. This is generally done by brushing it off, an operation which produces a siliceous lead powder that is very injurious to the health of the workmen who do it.

STOPPING OUT.

When we have to put on a ground color, by the process of dipping, upon flat pieces, or ware with large openings, such as plates, cups or fruit stands, it is not possible to entirely prevent the color attaching itself to those portions which are intended to remain white, we, therefore, have to make use of what is called stoppings. These consist chiefly, of a greasy material with which we coat those portions that are not to take the color. The coloring material suspended in water cannot attach itself to the ware except on those portions which have not received the greasy coating.

Formerly oil, or some similarly greasy fluid, was used, but oils penetrate the biscuit unequally, that is, they spread and the outlines of the stopped out portion cannot be kept sharp. Melted mutton suet, which sets directly it comes into contact with the ware, is used as a stopping with perfect sharpness and success. But in order that these stopped out parts can take, in their turn, an enamel or a glaze it is necessary to destroy the stopping by the action of a heat high enough to volatilize them, after which the ware is covered by a second dripping. This does not disturb the first coat as that becomes sufficiently set by the heat used for burning off the stopping. The work is then completed by firing in the glost kiln.

It is easy to see that we can stop out the first coat if necessary, should there be any fear that it will receive too thick a glaze from the second dip; also that we can put different colors in the stoppings. The principle is to cover with the fat all those parts, in the first, second, or third dipping, that have to be stopped out; being careful, each time, to destroy the greasy material by a sufficient, but always a gentle, heat.

At Nymphenburg in Bavaria, a different method was employed. This is by covering with glaze the portions which are to remain white, the blue ground color is taken up in a

brush and splashed over the whole of the piece. The glaze is then removed, by scraping or brushing, from the parts which are to remain white, whereupon the whole piece is dipped in a covering glaze, which covers both the white stopped out parts and the colored ground. We have seen vases and other kinds of ware with very fine and evenly laid blue grounds, put on in this way.

This stopping out, in whichever way it is done, is, necessarily, a delicate and tedious work, consequently it is expensive, this is entirely avoided by the first method, that of simple laying on of the color.

Sometimes we have to paint upon a colored ground, ornamentation of a different color; now, from the nature of vitrifiable colors it is very rare that one color can, successfully, be put upon another, for the color underneath will, frequently, act upon the one that is above it, even if the one color does not cause the other to shell off, which generally takes place when the underneath color is one of the kind we have classified as lard-fire colors and the one laid over it is a tender, or light-fire muffle color (see pages 51 and 98), the under color is seen, in consequence of the transparency of most vitrifiable colors and thus spoils the upper color.

In most cases the only thing we can do is to remove the ground by scraping it from those places where the other color is to be laid, but this method is very tedious and requires great skill, for it is almost impossible to repair mistakes.

We sometimes make use of another method; this consists in painting upon the white ware, with gum water thickened with chalk, those parts that we wish to surround witih a colored ground. The gum and chalk are incapable of adhering to the piece after firing. The design painted on in gum is allowed to dry completely and when it is perfectly dry a ground of color mixed with an essential oil, is laid over the whole piece, without any regard to the gum and chalk design. When the color ground is perfectly dry it is fired at a temperature sufficient to make it adhere. The ground will not fix itself upon any place where the chalk is, any of the ground color on this will not adhere to it and falls off of itself or becomes detached with the least rubbing.

We sometimes have recourse to another means, which is quicker and cheaper, inasmuch as no preliminary burning off is needed. We put a ground color upon the piece in the usual way and as soon as this is firm enough, but before it is quite dry, we paint upon it any required design with a thick solution of gum to which chalk is added; this is laid on with a brush. The piece is then dried in the stove and the gum contracts, carrying with it the chalk and the ground color upon which it had been laid, the ground not having yet firmly adhered to the ware. The design usually falls off itself and will always come away with the least rubbing, leaving a blank which has only to be gently dusted with a thoroughly dry dusting brush.

OVER GLAZE COLORS.

The fourth method of applying vitrifiable colors, that is colors upon the glaze, is the most used. It includes three kinds: Over glaze grounds for sharp fire; grounds for muffle fire, tender and hard and, finally, porcelain painting, from the simplest effects to the most precious works of art. We will consider them in this order.

HARD FIRE OVER GLAZE GROUNDS.

The colors called hard, or sharp, fire colors are applied upon the glaze, which is already vitrified and we have to re-fire the piece; the glaze melts again, the color becomes incorporated with it and partakes of its hardness, solidity and brilliancy, but this necessitates extra expense for firing the ware and renewed possibilities of accident and damage, nearly equal to those we meet with in the first firing. If we are working on a large piece which has taken a long time to execute, or is difficult to produce, the possibility of loss becomes much more serious, nevertheless, in many potteries, particularly those for porcelain, this method, on account of its simplicity, is generally preferred.

There are two general methods of application—we have described the special methods in treating of the colors which they require—in the first and oldest, only colors that are already vitrified are used and the ware, which is glazed and fired, is given a greasy, viscous, coat, called a mordant. That which was used at Sèvres, for hard porcelain, was composed as described on pages 130 and 137.

We first lay it on with a brush then distribute it so evenly as possible with a stippler, so that it is exactly equal in thickness all over, then let it stand for a few hours. We then take the color, such as deep blue, agate blue, or tortoise-shell brown, this is vitrified and then powdered, but not too finely: some of this is put into a sieve and dusted evenly over the ware. The piece is then fired in a sharp fire.

The first coat of ground is seldom equal in thickness, consequently the color is not all of equal depth. We then have to apply a second, thin, coat and again pass it through the sharp fire. Sometimes this makes it too deep and even almost black. The vitrified blue not only gives off blue vapor, like all cobalt blues do in the hard fire, but also a great number of very minute grains or dust, which will cover the white centers of plates, etc., and spoil them. We will speak of the other losses common to several colored grounds when treating specially upon this subject.

This process has, therefore, been abandoned for laying on blue grounds and has been replaced by the following: For this method it is necessary that the ware should be absolutely dry and the colors be finely and perfectly powdered. The deep blue, the pale bue, so-called agate, and the chrome green grounds are put on in the same way: the color, in the state of the prepared oxide, is ground with turpentine spirit until it begins to thicken on the slab, then we add fat oil in the proportion of a fourth of the volume of the cobaltic oxide. The color thus prepared is laid on the piece with a brush and is spread out and equalized with a long haired stippler, taking care not to pick off any of the color by an awkward use of the stippler, which would be likely to happen if we use one with short hairs. We then dry the piece in the stove and when dry give it a second coat, this time using less fat oil in the color. This is dried and then a third coat is put on, but this time the color contains more fat oil than either the first or the second coats did.

At Vienna they put on so many as five coats, but the result is their grounds are very fine and even.

For the pale or agate blue the same blue oxide is used, but it is ground up with about equal proportions of fat oil and laid on very thinly with an ordinary stippler.

Laying on Muffle Grounds.

The grounds for tender and hard muffle colors are laid on in much the same manner as those for sharp fire, but more care, foresight and skill are necessary.

The color is ground very finely and should then be reground on the slab by the workman who lays it on. It is mixed with the right quantity of essence. We have already spoken of the qualities of the essence and the effect of lavender; it is here that the employment of this particular kind, which retards the drying of the turpentine, is the most necessary.

The pencils that are used for spreading the colors are those known as fish tails, because they are flat and spread out like a fish tail.

Some colors are much more difficult to lay on than others, some are short, such as the blues and the grays, others lift up, such as the chrome greens, the purples, etc. The iron reds and browns are generally the easiest to use.

A most important precaution to be taken is to avoid all damp; the colors must be kept perfectly dry during the whole time that they are in use, particularly if a large surface has to be covered. This can only be done by keeping the workshop very warm, almost as hot as a stove, especially in damp weather. It has been noticed that even in the summer time, when the temperature of the shop was only the same as that of the outer air, that certain grounds could not be laid on with any success in the morning, nor on rainy days, nor when there were a large number of workpeople gathered together in one place.

It has also been noticed that it is often necessary to leave the prepared color, which is ready to be used, lying upon the slab for 24 hours, carefully covered to protect it from damp, before laying it on the vase

The same remarks will apply to gold.

PAINTING ON POTTERY IN VITRIFIABLE COLORS.

Whether the decorations consist of ornamentation without merit, of flowers executed in the worst possible manner, that is to say, the decorations of the commonest articles of commerce that have to be sold at the lowest price, or whether they are figure paintings or landscapes, which the art of the

painter has brought to the greatest perfection, there is one general end and aim to strive for, which is that the colors shall be bright, glazed and substantial.

It is more particularly of fine art painting, executed upon porcelain, that we intend to speak in this place, because the object is a higher one and one that can only be attained by taking minute precautions, which it is not even possible to enumerate completely.

The colors must be reduced to the greatest possible degree of fineness by careful grinding. This operation must be performed while protected from all dust and the powder must be thoroughly dry before the essence that is used as a medium is added to it. In order to retard still more the drying and make it easier to use the color, a little, very pure, olive oil may be added. This will not reduce the beauty of the colors, as might be supposed; indeed, we have even seen first-class artists, who have ventured to use the oil alone as a medium, taking the risk of the least touch or rub destroying their work.

The application of the color is of the greatest importance, and this is an operation which cannot be described, as it depends entirely upon the intelligence, the touch and the skill of the artist. As painters say, it must be free, light and even. The greater number of colors, prepared by chemists, which are submitted as samples, are nearly always bright and well glazed because these samples have been prepared without any regard to lines or forms to be observed, of tints to be obtained, or of retouching, that we must be prepared for. Therefore, at Sèvres, we never form our opinion as to the acceptability of these colors from the samples, but only from trials that have been made on a small scale by a painter for this purpose and with all the blendings and mixings that will, possibly, have to be employed.

Colors that are laid on with the pencil are always better glazed than those that are dusted on.

There is no art painting that should not receive at least two firings, and more often three, if we wish to give it the perfection of which it is susceptible; sometimes it receives four and even five, but these are exceptions and greatly increase the risks in painting upon hard porcelain.

Nevertheless, when these firings have been foreseen and the painting has been prepared as it ought, the hardest colors be-

ing put on for the first fire, following this by at once laying on
the tints of their right intensity,without seeking to obtain them
by superpositions of the same color, a process which only in-
creases the thickness of the color without giving it much more
depth or intensity; if we have been able to avoid the laying on
of one color over another, which often deteriorates and some-
times even destroys them, we may have a chance of proceed-
ing to the fourth firing, should this be necessary, without a
mishap. In any one firing we must always use colors of the
same degree of fusibility and be careful, for instance, not to
put in the lights with fusible colors and the shadows with hard
colors. A firing that has to follow a first firing so badly ar-
ranged as this will never set things right.

There are some brilliant and vigorous colors which can only
be obtained by superposition. Thus we can never get a pur-
ple, either pearly or amaranth, nor a beautiful and deep vio-
let, with a single color. We must first use the red or brown-
red iron colors, such as orange No. 55, blood red No. 58, or red-
dish brown No. 68, and glaze them in the second fire with the
purple or violet colors of gold, but never with gold carmine,
which will destroy them.

As we have observed before, the painter is exposed to acci-
dents or imperfections which we have designated as scaling
and want of harmony or terne Scaling will never occur if he
lays on his colors thinly and evenly, without trying to get too
great a thickness all at once

The shades of color should be prepared beforehand. Thus
if it is a question of a red bowl he should commence by making
the light with blood red 58 and yellow 47, the half tint, blood
red 58 alone, the half tint of the shadow with 58 and reddish
brown 68, and the deep shade with 75, introduced in the mix-
ture of 58 and 68 to intensify the tint

In this way we have an object that is colored by the tint and
not by the thickness of the coat of color, where we have no
risk of scaling. We can, if an amaranth bowl is required, pro-
duce this by reglazing it with purple in the second fire.

Precautions in the succession of application of colors of more
and more fusibility will also prevent the appearance of terne.
· As to this unpleasant effect, it is often the result of a bad
mixture of colors, which react the one upon the other, or from
the superposition of colors having this defect.

It is impossible to give a rule for mixing; there will be differences for each painting of figure, of flowers, of landscape. No prescription can regulate the matter with certainty. The painter who works for his art must not be afraid of trying all the mixtures which offer any probability of giving him the tint he seeks. He must make careful notes of these mixtures and their proportions, be quite certain of the degree of firing they have received and not spoil it all by overlaying colors for his second fire, which he does not know by experience or has not tested.

These general rules will suffice for our object. The complete enumeration of all that we must know and do to succeed in the production of art painting on an industrial scale would require a special treatise, which would still be insufficient without study, tests and experience.

There is a kind of painting in vitrifiable colors, which bears about the same relation to that we have just treated of as a gouache does to a water color.

The colors for painting upon porcelain are transparent. Those of which we are about to speak are almost opaque. They owe their opacity to their property of mixing together with white for mixing, No. 4, also called Chinese white, which forms the base. We can, by introducing this white in the greater number of the muffle colors, give to them that remarkable thickness which we see in Chinese paintings and which has recently been very successfully imitated. What is more important is that we can paint on a large scale, in the manner of oil painting, upon porcelain biscuit and upon large flat plates, doing good work with even more ease than upon glazed plates.

But these paintings are inferior to those done on glaze, because they are far from possessing the fineness of the latter; they always show something of the heaviness of the gouache and of paintings upon earthenware.

GILDING, PLATINIZING AND SILVERING.

These metals are brought to the state of a very fine powder, as described at page 111, and ground on the slab with flux No. 7 (p. 47) in the proportion of 1-10 to 1-13 of the metal; but with the addition of a little borax for the platinum and of 1-10 for the silver.

The grinding of the gold is more difficult than grinding colors, for if we do not possess the right touch we pack the fine grains of gold together: these become flattened beneath the muller, forming small scales, the use of which becomes extremely difficult and the polishing almost impossible.

If the precipitation has been properly carried out, if the gold is very fine and the grinding, or any other circumstance, has not compacted the molecules, there will be no difficulty in using the gold economically, and it will be easy to burnish it so as to produce a brilliant polish

The gold is laid on with either a common or a sable pencil. It will be necessary to know how to use it very well to produce, with such an instrument and with a heavy material, such fine lines and such complicated forms of pure design as our skillful gilders are able to give us.

To make it flow more freely we add a little lampblack to the gold. This addition is almost indispensable when we gild upon a sharp-fire chrome green, in order to see more distinctly the lines we make.

Gilding is most usually done on the glaze, sometimes it is put on the colored ground. If it is a sharp-fire color the firing will not differ from that of gold laid on the white, but if it is on tender muffle colors the firing will be much more difficult, for it must be carried far enough to make the gold hold, without at the same time allowing it to sink into the color, which has been softened by the fire, and without permitting the color to boil. It is therefore a very delicate operation and too often results in a failure. But on the hard muffle colors gold is fired as easily as upon white; it holds securely and burnishes well.

When the gilding of a piece is finished it is fired in a muffle. A temperature, higher by at least several degrees, is necessary for firing than is needed for the hardest among the ordinary colors. Therefore, for all good, sound work the gold should be fired before even a sketch of color is laid on, in order to be master of the work and give the colors the heat they require. This is the constant practice at Sèvres.

If the gold is not fired sufficiently it will not hold at all, if it is slightly underfired it may hold on being taken out of the kiln, but it will very soon wear off in use. If it is fired too much it becomes too hard and rough, it polishes with difficulty and badly.

In firing the gold in the way above described we use more fuel, consequently the gilding becomes more expensive. If to the economy resulting from firing at a lower temperature we add the method of reducing the employment of gold by mixing silver with it and laying it on very thinly—this can be done easily by making it more flowing through the use of mercurial gold, or the addition of lampblack—ware is obtained which, on leaving the shop, possesses a great deal of brilliancy, but very little durability.

BURNISHING THE METALS

Gold that is laid on with the pencil in the metallic state is matt after firing. If it is intended that the matt condition should be a part of the decorative effect; this is obtained by the process we have given on page 114 in order that it should be very fine; it is then burnished in parts, but if the gold is to be brilliant instead of matt it is burnished all over, rubbing strongly, but skillfully and evenly, in order to produce a surface that is equally polished everywhere and without any marks or scratches. This operation is very difficult when large surfaces, called gold grounds, have to be polished. For this purpose we make use of tools that are used in a number of arts; these tools are called burnishers. We give some examples of these: 4, 5 and 6 are agate, the others, 1, 2 and 3, are of a hard hematite, known by the workmen as blood stone.

The first rubbing is generally done with the agate burnishers and the finishing is done with the hematite tools. When these burnishers have become, as it were, dirty from use and do not polish well, their original smooth and polished surface is restored to them by rubbing (buffing) them with a leather and putty powder (tin oxide).

When the piece is perfectly burnished it is cleaned with whiting; this must be soft and well washed, so that it contains no sand or anything that will make scratches.

Some times the gold comes off when burnishing, and it is a troublesome matter to correct this fault. There is indeed nothing else to be done but remove all the gold, either by rubbing or by dissolving it off, then regild and fire it. If the piece has no painting on it this is easy and efficacious, but if it is a painted piece at its last firing we run a risk when burning on the gold. We then have to put in more flux, often causing the colors to scale off. We therefore are careful to test the adhesion

of the gold by burnishing it at several different points before commencing to paint, particularly if the piece is very valuable.
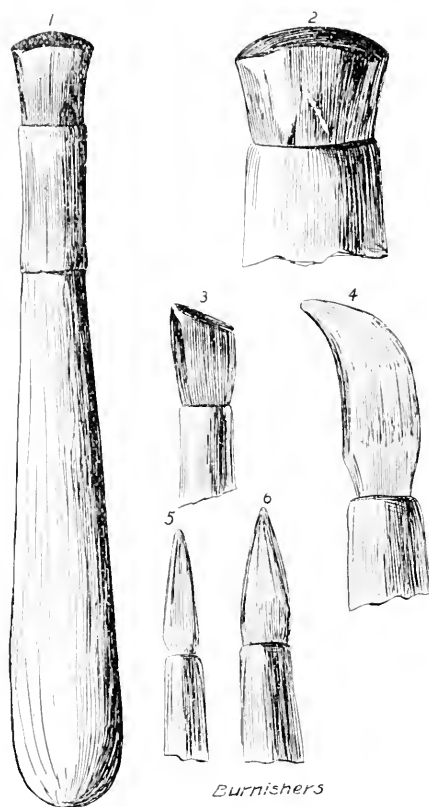
Burnishers

Although the burnisher's art does not appear to be very difficult yet the women—for burnishing is nearly always done by women—who do this work show considerable differences in degree of ability possessed by them. There are very few who can do good work on the gilding of cups. Some of them, who are said to "burn" their gold, are much more liable to the accident of lifting, or scaling off the gold than others are.

At Meissen and at Berlin an endeavor has been made to shorten this operation, at least for the bands on plates, by putting the piece in a lathe, in such manner that the piece revolves under the burnisher, which is held by the workman. In the accompanying figure we give an idea of the arrangement.

The gold, in burnishing, spreads out, and if this spreading out is not pretty nearly equal throughout, those portions which are strongly compacted will separate from those which are less so.
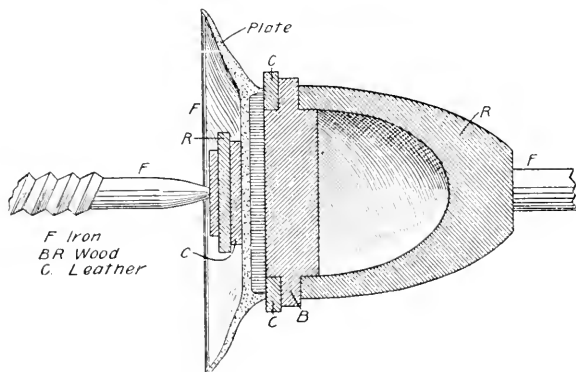
Chuck for Holding Plate While Burnishing

Printing in Colors and in Gold.

This process, which consisted in transferring prints made in vitrifiable colors on engraved plates was tried in England, first at Liverpool and then, about 1751, at Worcester, at the porcelain works established by Dr. Wales. It was, shortly afterwards, introduced in the Staffordshire potteries. In 1760 the process of printing upon enameled earthenware became known at Mariberg, Sweden. In 1775 Bertevin, an employé at the hotel des Invalides, communicated it to M. Parent, at that time director of the royal manufactory a Sèvres. It was used in 1777 to print the outlines of antique heads, after the

manner of cameos, upon the magnificent service ordered by Prince Burlatinsky for the Empress of Russia

This process remained in abeyance in France, and was almost ignored there, until about 1806; it was in 1808 that Potter taught the manufactory the method almost the same as it is practiced to-day, and which we will describe. The process has, since then, been improved in some details. It is now carried to a high degree of excellence, and its use has been immensely extended, first in England, then in France and Germany, though less in the last country than in the other two.

It can be readily understood what an immense advantage it was to be able to print with the rapidity of ordinary copper plate printing the most complicated ornamentation, which could be as perfect as the art of the engraver was capable of making the plate, and that turned out decorations by thou sands.

Nevertheless there are difficulties and obstacles present themselves that are not met with in ordinary copper plate printing, in which the damp paper has only to be applied to the surface of the plate and picks out from the lines of the engraving the ink that has been deposited there, with one stroke of the press the work is done In printing on pottery it is necessary that the design engraved on a body that is flat and rigid should be transferred to another body that is rigid, but not flat; this necessitates two important operations instead of one. The first is the ordinary operation of copper plate printing, that is to say, transferring the design engraved upon the copper to the paper; the second is the transfer of this "proof" on the paper to the pottery, whatever its shape may be, that is to say, to an inflexible body with a hard and polished surface, possessing all sorts of sinuosities. This surface has to take away from the paper the impression it received from the copper plate, and it must take it away completely and promptly. We will show by what series of ingenious methods that have in practice been rendered more and more simple, we have succeeded in attaining these results.

Considerable modifications had to be made in the engraver's art and in copper plate printing from the engraving of the

plate to the impression upon the ware, whether in vitrifiable colors—consequently in colors that are heavy and hard—or in gold; in the latter case it was necessary to have not simple lines, but fairly broad surfaces, capable of giving by their aspect and burnish all the advantages that result from the brilliancy of the metal. We will see how this is done.

Engraving.—The first modification in the application of engraving to printing on ceramic ware commences with the engraving itself. We can, if necessary, use any kind of engraved plate, but when the plates are intended especially for this purpose they should be engraved to varying depths, in order to vary, somewhat, the intensity of the colors; then the lines should be kept so far apart that there is no risk of their running together during the numerous operations they have to go through. This is particularly the case when we are printing in gold.

The colors used, being oxides, are hard, some of them are vitreous; they wear out the plates very quickly, so that steel plates are preferable to copper

Printing Ink.—The copper plate printing ink, charged with vitrifiable colors, instead of the usual organic or earthy colors, requires a special and very careful preparation to ensure the success of the printing upon which the quality of the ink has a great influence.

The first operation is to boil the oil to bring it to the right degree of viscosity.

At Sèvres we use either linseed oil or nut oil, the latter is preferred. It should be good and fresh: it at first possesses a kind of unctuousness, which it loses in the first stage of boiling, but it becomes more tenacious as the operation goes on.

The quantity of oil that we wish to prepare is poured into a cast iron pot, but taking care not to put in more than two-thirds of what the pot will hold, it is then placed over a clear, but sharp fire, and the oil soon begins to boil; it becomes hotter and hotter and thickens. When we judge it to be so hot as to be on the point of catching fire, we clarify it and reduce its viscosity by throwing in some slices of ordinary bread. The bread is thrown in while the oil is still over the fire, and the slices must not be put in altogether, but one

after the other. The number and size of the slices are pro
portioned to the quantity of oil that is to be prepared; thus
two or three slices, measuring 3 in. or 4 in. by about ½ in.
thick will be enough for a kilo (2.2 lbs.) of oil. The bread
becomes browned and fried and the oil is cleared. We judge
as to the condition of the oil, both the color and the viscosity,
by taking up a spoonful from the pot at frequent intervals.

The clear, yellow oil is kept on the fire until it reaches the
temperature of self-ignition, and is allowed to burn for a few
moments. The pot, with the oil still burning, is taken care
fully off the fire and set upon the hob of the furnace. The
pot is then covered by putting on the lid. The knob of the
pot lid is held all the while, either with pincers or a wet
cloth, so as to be able to take the lid on and off, successively,
four, five or six times. When the lid is taken off the oil must
burst into flame again, and if it does not do this of itself it
may be stirred with the iron spoon. If it is not hot enough
to ignite spontaneously, it must be set over the fire again.
This treatment is continued until the oil becomes viscous and
of a chestnut color by absorption of the lampblack that is
formed in these repeated smothered ignitions. We judge
whether the oil has the required properties by putting some
of it on a white plate; according to its lighter or darker color
we divide it into weak, medium and strong, according to the
colors or metals for which we have to use it.

Inking and Pulling the Plate.—To ink the plate we take
one of the above mentioned qualities of oil, as much as we
judge to be needed, and add to it on the slab the required
color. The necessary bond between the color and the oil is
supplied by the addition of a certain proportion of lamp-
black; this varies according to the color we use: thus for
blue we put, to ten parts, by volume, of the color one-tenth
of lampblack; for gold we add one-third: with black, green
or red we do not put any. The mixture has the oil added,
and is ground, thoroughly, on the slab with a knife or muller.

Bone black, known as ivory black, which is used for copper
plate printing on paper, cannot be employed here on account
of the phosphate of lime it contains.

The strongest oil, which dries more slowly than the others.

is used for gold. This allows us to dust all pieces together, and some time after they have been printed.

The colors are, as a rule, the same as those used for ordinary hand-painting of the different kinds of ware, except that they have more or less flux added to them, according to whether they have to be applied to the biscuit or on the glaze and according to the nature of the glaze. The copper plates are inked, either with the finger or a cork; they are seldom large enough to require a wad.

The superfluous color is cleaned off the plate, either with a large and very flexible steel knife, the front of which is cut to a long bevel, with the edge perfectly straight, or else a wooden spatula, of similar form, is used. Whether it be with the spatula or the knife, the color is taken off the surface of the plate almost at one stroke, and all we have to do is to give a final cleaning with a rag or the hand.

In order that the rag, which is usually of muslin, should not go into the engraved lines and take out the ink, we press lightly. This gentle rubbing does not prevent the cloth taking off the color on the plate, but it does not allow it to pick out the color in the lines.

These operations are common to all the different methods of printing, but there are four kinds of printing which differ considerably from each other and require different treatments.

These are.—Printings on paper, on gelatine, printings on the biscuit, and on the glaze.

We will take first the printing upon paper; then upon the glaze; after this upon the biscuit, and, finally, that which is done by means of gelatine.

PRINTING UPON PAPER AND TRANSFERRING TO THE GLAZE.

Pulling an impression upon paper has nothing special about it, but the choice of the paper upon which we pull our proofs is very important. This should be of the kind known as "Joseph," that is to say, a paper with a fine texture and absolutely unsized. It must be properly damped. Formerly it was made to undergo various preparations. such as salting, soaping, etc., but it is now recognized that all these are useless. So soon as the design is upon the paper this is put in water, or rather it is laid upon the water.

We then prepare the ware to receive the impression, by covering it with a species of mordant, which at Sèvres they call "mixtion," to which a twelfth of copal varnish is usually added; this coat is thoroughly dried in the stove. Practice has taught us that this coating is not indispensable, either upon earthenware or porcelain, but it makes the work of transferring easier. A saline mixtion can be substituted for this, as was done at Sèvres by Master-Printer Tristan; this is simply a weak solution of alum, which dries very quickly without any need for stoving.

We take the paper bearing the proof and drain off the excess water, laying the proof upon blotting paper or on a piece of flannel, or, better still, upon a piece of unglazed porcelain biscuit; it is then applied to the ware in such manner that the design or engraving is in the right place. The transfer of the engraving is effected by pressing upon the back of the paper with a wad of felt or with a small roller; the paper is easily pulled off, but if it should resist a little it is slightly moistened again. The engraving which it bore becomes entirely trans- ferred to the glaze of the pottery, after this there is nothing more to do than fire the piece in a muffle. In order to fix the gold on firmly, or to glaze the lines of the print (should this be considered necessary), the firing must be rather sharp.

Gold decorations are printed in the same way, with some modifications in several of the processes We generally use the precipitated gold, which is mixed in the boiled oil that we call mordant, adding, as was said above, a third in volume of lampblack. The gold should have about one-fifteenth of flux added to it.

But if we content ourselves with the small quantity of gold which enters into the compound of mordant and lamp- black we would have, after passing through the muffle fire, gold lines that would be extremely light and poor. We must, therefore, strengthen the gold by a method which we owe to Legros d'Anisy. We take a small quantity of the gold in powder: this must be very fine and very dry; after the gold design is transferred to the ware, while it is still in a viscous state, a fine pencil is dipped in the gold and passed over the lines of the design. The whole is then brushed off with a dusting brush to remove the excess gold and any that may

hang to the parts that are not to be gilt. This gold only con
tains 5% of flux, and must be ground up in nothing else but
water; it covers the lines well, and even broad spaces if these
are filled up with lines or dots close to each other. This gild-
ing will take a burnish as even and as brilliant as that which
is laid on with the pencil, and wears almost as well. This we
have proved by submitting some plates on which the two
methods of gilding had been applied side by side, to continuous
wear for six months in ordinary domestic use.

This dusting on of the gold does not increase the cost to
any appreciable extent, and it is almost indispensable if we
wish to produce a beautiful, solid and durable gold. The same
thing is done for colored decorations, in order to give more
body, both to the color and the glaze.

PRINTING UPON PAPER AND TRANSFERRING TO THE BISCUIT.

This method of printing, which is the principal one used in
all the potteries where the ware is fired twice,—the first time
for biscuiting,—requires entirely different qualities in the
paper and its preparation. It must not be sized, but instead
of being soft and, in consequence, woolly and not very ten-
acious, it should, on the contrary, be very tenacious; it should
possess a tenacity that will make it difficult to tear it. Up to
the present time a good quality of this paper appears to be
only made in England. The printing ink is very viscid, and
it seems that there is pitch in the mordant, as in that given
on page 134.

The proofs should be pulled as rapidly as possible, in order
to keep the transferrer supplied, therefore endeavors have
been made to shorten the operation as much as possible.

Transferring upon the biscuit of fine earthenware and of ten-
der porcelain is much easier than upon glaze. The matt sur-
face of the biscuit does not always need to be prepared. The
vitrifiable color does not have any flux mixed with it, as the
glaze with which the piece is covered makes this unneces
sary. The paper cannot be pulled off without tearing it and dis-
turbing the design; the only way to remove it from the ware
is to plunge it into water and allow it to remain for some
time. The operation of printing, which is carried on upon a
large scale in the manufactories of fine earthenware and ten

der porcelain, has been shortened by the use of a number of little dodges, which become quite important when the work is done so extensively. At Longport a plate is printed in eight seconds.

As the glaze is mixed with water it will not take upon the lines of the engraving made with a greasy ink. We are therefore obliged to pass the printed biscuit through a clear fire, hot enough to burn off the greasy matter before we dip the piece in the glaze. This is an extra firing that it has to undergo, but it is not an expensive one. In the potteries where this kind of decoration is done on a large scale they have rauffle kilns of between five and six feet high that are used only for burning off the printing ink before dipping the ware in the glaze.

PRINTING ON GELATINE.

This process is longer than the two preceding, but it has two advantages over them; firstly, it gives much sharper prints; secondly, it does not wear the copper plates

We prepare a clear solution of Flanders glue, or of gelatine made from clippings of glove-leather or parchment. This must be of the consistence of a thick syrup. It is poured, while warm, into earthenware plates or upon a smooth slab or any other material with a smooth surface so as to get a sheet of gelatine about an eighth of an inch thick and of the stiffness of India rubber.

The copper plate is now inked—just as though we were going to pull a proof—with a boiled, drying, nut oil, mixed with a very little essence of turpentine. This is wiped off with the hand in the way that copper plate printers do. It will be noted that nothing has been put into this oil, and consequently there is no vitreous nor vitrifiable matter in the engraved lines.

The plate of gelatine above mentioned is now applied to the copper plate charged with the thick oil, or the plate may be applied by a rolling movement upon the gelatine to which a convex surface has been given by fixing it on a half cylinder of wood covered with flannel. Or we can pull an ordinary proof upon paper and counter proof this onto the gelatine by pressing it with a roller.

Whether by the one or the other process and by the aid of

a slight pressure, either with the roller or simply with the hand, we transfer the design engraved on the copper plate to the sheet of gelatine. It must not be forgotten that the plate was only charged with oil.

We then take the sheet of gelatine that has received the impression and lay it upon the ware upon which the design is to appear, pressing it down firmly and evenly. The design in oil leaves the gelatine and fixes itself completely and very sharply upon the ware. We remove the plate of gelatine, and as the oil with which it was charged is transparent we can scarcely see the transferred design.

We then take up some vitrifiable color on a wad of very finely carded cotton wool. The color is reduced by grinding to the state of greatest possible tenuity, and it must be perfectly dry. We dust the color onto the piece, where the design is. The color only attaches itself to the oiled portions forming the design, where it is securely held. The superfluous color is easily removed with a dusting brush. The design is new shown complete, accurate and sharply defined in vitrifiable color to which there is nothing more to do than burn it onto the ware.

We can put any kind of vitrifiable color upon the oil design.

The color must contain a flux if the design is executed on hard porcelain.

We can also apply gold in the same way, instead of colors, with very satisfactory results.

ENLARGING AND REDUCING GELATINE PRINTS.

A copper plate printer named Gonord, early in the century, discovered a remarkable application of the gelatine printing method by pulling proofs from the same copper plate, which were larger or smaller than the original engraving and yet were perfectly regular. He kept his process a secret for many years and no one was able to guess it. It was afterwards published in a record of patented inventions, but the description is so complicated that only one thing is clear, this is the property that gelatine possesses of swelling regularly in cold water and of contracting regularly in alcohol. Taking advantage of this property we have used the Gonord process at Sèvres, but in a much simpler and quicker manner. A solution was made of

gelatine from parchment clippings, which is the best as it gives a clear solution. When it is of the consistence of a syrup, it is spread in thin coats upon smooth plates of copper; on cooling it becomes reduced to a sheet not thicker than a sheet of stout paper. The engraved plate is inked in the usual way with vitrifiable colors and a proof is pulled on unsized paper. The paper is placed in a thoroughly wet state, upon the gelatine and, if we wish to have an impression the same size as the engraving, we transfer it at once by pressing it with the roller as before described and then immediately place the sheet of gelatine on the ware, upon the surface that has been coated with mixtion, and the transfer is completed in the usual way by pressing with the hand or a roller, but if we wish to have the proofs larger or smaller than the original we proceed as follows·

For Enlarging the Proof:—The sheet of gelatine is laid upon water, with the printed side uppermost. A border forms all around which prevents the water touching the printed surface and enables the gelatine to float. It will be seen to spread out in every direction with great regularity In about an hour's time it will have got to its full size, which will be about a third larger. It is then taken out, by slipping a sheet of transfer paper under it, taking care not to wet the printed surface; this printed surface is then placed on the ware and the impression is transferred in the usual way. To remove the gelatine the piece is put into hot water; the gelatine dissolves entirely and the impression remains sharp and clear on the glaze of the ware.

Reducing the Print:—To do this we proceed in exactly the same manner, but lay the gelatine on a bath of alcohol instead of water; taking the same precautions to prevent the surface on which the print is from becoming wet it will be seen that the sheet will draw together with perfect regularity and in less than half an hour it will be about a quarter smaller. We must take care that no alcohol gets on the front of the gelatine for this would spoil the mixtion and prevent the transfer being properly made. The transferring is done in the usual way and the gelatine is dissolved off in hot water. The impressions are quite sharp and they can be strengthened by dusting them

with powdered color or with gold, as was described in another case.

It will be seen that this process is a slow and tedious operation and is, consequently, rather a curiosity than a commercial process and it has been but very little used.

FIRING THE COLORS.

The firing of vitrifiable colors has degrees of importance and difficulties which differ very much according to the wares upon which they are applied. Whatever these goods are, the firing should be exactly correct in order that the colors should possess the beauty, durability and brilliancy that we have the right to expect from them, but in general there is very little latitude between the time when the firing is complete and that when it has gone too far. This small latitude makes the operation the more delicate in proportion as the limits are more restricted, as they are where the piece to be fired is painted with greater care and a nearer approach to perfection.

We have already said, in classifying the colors under three groups according to the degree of temperature at which they are fired, that one of these groups is called hard fire or sharp fire colors, because the color is applied on ware that has to be subjected to a fire intense enough to burn the ware.

There remain, then, the colors that are called muffle colors; these are of two kinds, hard and tender; they are both fired in the same description of kiln. It is this muffle kiln that we will now describe. The heat that can be given in this kind of kiln extends from a dull read to the melting point of silver, or from 3° to 6° of Wedgwood's pyrometer.

MUFFLE KILNS FOR VITRIFIABLE COLORS.

The kilns that are used for firing colors may be divided into two classes. In the first are those with fixed muffles, which are nearly the only ones used throughout Europe. The second class contains the kilns with traveling muffles. The use of these has been abandoned, but as it is probable that they will, some day, come into favor again, we will tell what we know about those that have existed.

Fixed Muffles:—Muffles are species of rectangular boxes made of burned clay, with a round or vaulted top. In those of Sèvres and of Paris, the plate at one end serves as a door

by which the ware is introduced. This is closed by luting it with clay.

The box, or the muffle, is the laboratory. The furnace is generally below this. The door or mouth of it is in front, underneath is the grate and below this is the space for ashes. The entrance to the chimney is generally obstructed by a plate with a number of holes in it, this plate is above the muffle and a short distance from it. A tube is fixed in the top of the muffle to permit of the escape of any moisture that might be formed in the muffle. Arches over the furnace support the muffle and there is a space between the walls of the kiln and the muffle.

The English muffle kilns for tender porcelain are differently arranged, A. is a sectional elevation and B. is a plan of the furnaces. These are shown at F., there are four of these on one side. The coal is thrown upon a grate. Some of the heat passes through the narrow space G. in front of the muffle, the
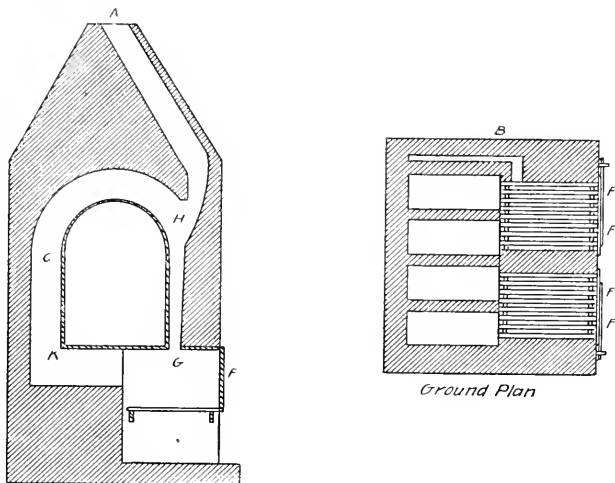
ENGLISH MUFFLE KILN.

rest of it goes under and around the muffle by the larger space C., to reunite with the flames that went up the front and escape at the vertical chimney H. These muffles are of fire

clay, but are closed by means of cast iron plates, which leave a space as an escape for the gas produced by the volatilization of the essences.

In Germany the muffles are placed in a kiln fired at the side. They are unnecessarily complicated in construction, as is proved by the fact that we can do very good firing with the much simpler muffles used by us.

Muffles are usually made of clay, that is to say of a good quality of fire clay, that is refractory enough not to melt nor to soften in a strong fire; above all it must not contain lime, pyrites nor bitumen, which might, from various causes, have an effect upon the colors. (It is very rare that a clay which is darkened by the presence of bitumen or coal does not at the same time contain pyrites). The clay may have its plasticity reduced by the addition of sand, but only in small quantity, it is with ground calcine, well burned and made from the same clay of which the muffle is made, that the plasticity of the clay should be reduced. The calcine is ground to a suitable degree of fineness, according to the size of the muffle to be made.

At Sèvres we use two compositions, which slightly differ according to the size of the muffle. The ordinary muffles are composed of—

> Plastic clay from Dreux........................37
> The same clay, well burned and coarsely ground..39
> The same, but finely ground....................24

This material shows a shrinkage of 9 per cent in the biscuit kiln. The large muffles are composed of—

> Plastic clay 35
> Finely ground calcine..........................65

This material has a shrinkage, after drying, of 10 per cent.

The muffles are made by laying the clay, very carefully with the hand, on the inside of molds of either plaster of Paris or of wood. The view hole or tube is made on the wheel and stuck on afterwards. At Sèvres we have two kinds of muffles in general use with which we are quite satisfied; the one is used for firing pieces of moderate dimensions, the other kind is for firing plaques or round tables in one piece, which are more than one metre in length or diameter. Pieces of this size require a muffle that is very much higher than it is wide. Our illus-

trations show a front view, a sectional elevation from the front and an elevation section seen from the side of the ordinary muffle kiln used at Sèvres and Paris; m is the muffle, f the furnace, b the fuel door, c is the air supply and ash box, c' is a removable grate for taking out the ashes, g is the iron grate, p p are grooves in the brickwork enabling the grate to be set higher or lower as desired, a a a a show the arches over the fire, that support the muffle, e e is the free space between the muffle and the kiln walls for the circulation of the flames, l is the escape for gas or steam from the muffle, f is the quirk or jamb into which the door or plate for closing the muffle fits and which is afterwards daubed tight, h is a perforated plate forming an arch over the muffle. The plate which closes the front of the muffle is in three pieces, w w' w'', which before being put into place and luted are held together, temporarily, by a rod t, v and v' are view holes.

These very large muffles are not only very difficult to make, but they show large and irregular cracks from the first time of firing, it is, therefore, better to make them in several pieces, put together with a paste of fine calcine mixed with a little litharge, in this way we avoid the cracks, or if any appear they are short and do not open up much.

The cracks which appear in the clay muffles, after they have been in use a certain time, have caused endeavors to be made to find some other material and muffles have been made in cast iron and strong sheet iron.

The casting must be of a metal that does not give off any sulphurous, arsenical, or carbonaceous vapor. Black iron is better than white, as the latter is more brittle and more likely to be broken by a blow or by a sudden change of temperature, but these muffles are capable of weakening, of getting out of shape and even of becoming cracked.

Muffles of strong sheet iron have also been made; these are covered outside with a lute of clay; they can be used for trial muffles for small pieces, but they very soon get out of shape and drop scales of iron oxide on the ware that is being fired.

TRAVELING MUFFLES.

I designate these muffles by this name because they are carried on iron runners or sleds and they are passed through a long furnace with lateral fires, as well as below. The middle

portion of the kiln is kept constantly at the temperature necessary to melt the colors or the glaze. The chambers or portions of the kiln where the muffle enters and leaves are kept at a much lower temperature, so that the ware is heated gradually before firing and cools off slowly afterwards, thus preventing cracks from too sudden changes of temperature. A very remarkable kiln of this description was used at Sèvres for a long time for firing the painting and gilding on both hard and tender porcelain, but it was much too complicated. It was built at Vincennes in 1751 under the direction of a man named Gerin, a very intelligent workman, who came from Chantilly and, according to Hellot, was the possessor of all the receipts and methods of manufacture of tender porcelain. The kiln was removed to Sèvres when the manufactory was established there about 1756.

The boxes or saggers of clay, 78 centimetres long by 48 wide and 40 high were filled with pieces to be fired; these were kept separate by stilts. At most, 20 plates of tender porcelain were put in a sagger or 60 of hard porcelain. When one of the boxes was filled it was first warmed in a special kiln, then it was put into one end of the firing kiln and passed successively through the four chambers, the heat increasing in each one, until it arrived at the center chamber where the principal fire was; there it was allowed to remain a sufficient time for the contents to be completely burned. The temperature was judged by the color of the fire. In order to judge correctly it
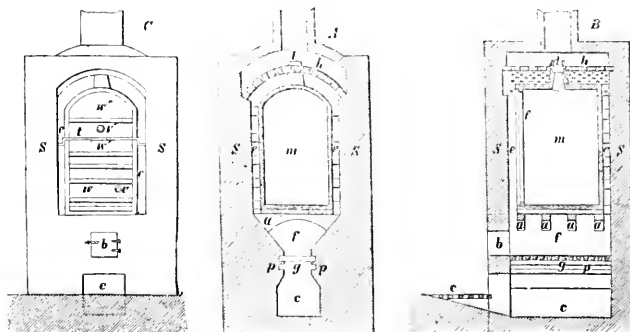
MUFFLE KILNS.

was necessary to have a great amount of practice, which reduced the number of firemen capable of undertaking this responsibility, to one or two persons. I had a trial piece attached to each box, which could be drawn out, by a tongs through the view hole. When the trial pieces showed that the burning was complete the box was moved on from the center of the fire through the four chambers, each one cooler than the one preceding it. The chambers were formed by letting down partitions through slits in the roof of the kiln. A partition was lifted up to allow a box to pass from one chamber to the next, and in this way each chamber was kept at the temperature needed, the chambers gradually increasing up to the central fire and the degree of heat becoming lower towards the exit, for the purpose of annealing the goods. The principle acted upon was to keep each portion of the kiln at a certain temperature, without having to lower this for the purpose of drawing the finished ware and reheat it for the new pieces; on the contrary the same heat could be kept up night and day so long as there was porcelain to be fired. After having conceived such an ingenious idea and put it into execution at enormous cost they did not appear to know how to profit by it, for the firing was stopped every night and on Sundays. I kept it running without interruption, by using relays of workmen in eight-hour shifts and providing an assistant for the chief burner; nevertheless I found that there were serious disadvantages connected with the use of this kiln, which compelled me to abandon it.

In the first place, in order to get the full benefit from it, it was necessary to keep up the firing continuously for, at least, 15 days. This required either an immense output, or else the burning had to be done at such great intervals between each, in order to accumulate sufficient ware to be burned, that the general management of the works was seriously inconvenienced. Although I gave this method of burning a thorough test, by firing continuously for 15 days, during which time 218 boxes, containing 4,840 pieces of all kinds, principally plates, were passed through the kiln, and this in the month of November, consequently under the most favorable circumstances, I found by a simple, but exact, calculation of all the expenses, that the cost of firing a plate with a gold band was

25 centimes for hard porcelain, which is more than the cost in the ordinary muffle, while for tender porcelain, in consequence of the distance that had to be kept between the pieces, the cost was 60 centimes.

Le Gros d'Anisys took up this principle of traveling muffles and built at Paris, in 1809, a kiln with four chambers in a row, this was not so heavily constructed as the one at Sèvres. The heat in the two central chambers was high enough to burn the ware, the chamber at one end was hot enough to prepare the goods for the sharp fire, while that at the other end served as an annealing oven. A train of five boxes, drawn by chains and pulleys contained a large quantity of fine earthenware. The plates were put in iron cages, supported by projections, which barely touched them. In one of these boxes a great many more pieces were fired than by the old system. These works for the decoration of fine earthenware did not run for very long and the kiln, which I saw working with perfect success, was pulled down. Since that time I do not know of any further attempts being made at using a similar system.

Setting in fixed muffles and, probably, also in the traveling muffles, requires to be considered from two points of view; in the first place we want to put as many pieces in the muffle as possible, having due regard to the shape of the pieces, their fineness and the quantity of color on them. Those pieces which are merely decorated with gold can be set quite closely together, but those that are charged with color must be further apart so that the essences (oils) can evaporate and also that the vapors given off by them shall not affect the colors. It is necessary to know how the heat distributes itself in the muffles in order that the setter may put his ware in the place where it will get the right heat for firing. We have to be careful when setting not to form a transverse enclosure, floor or diaphragm, which will divide the heat.

The ware should be set, so far as possible, in such manner that any dust entering the muffle either before or while the colors are in a state of fusion, should not strike them. The general inclination is to set flat pieces, such as plates, saucers and dishes, horizontally, with the painted side downwards, but we have been assured that in this way the colors receive the direct current of the ascending vapors, which form

in the muffle and some into contact with the painted portions, alter the colors and prevent glazing, though we have not, ourselves, been able to establish anything on this point.

We must also avoid using plates of terra cotta or even of biscuit porcelain for supports to the ware. They sometimes have an injurious effect upon the glaze of the colors by absorbing the flux. I have seen a fragment of a new brick, that had been thoroughly put in a muffle, destroy the colors and produce very serious damage.

It is for this reason that, in many cases, the interior of a muffle has a coat of red oxide of lead (minium) given to it, which prevents this absorbtion. I have seen this method succeed with the very large muffles, but we have seldom had to use these coatings, they are sometimes made with borax.

It is very rare that a new muffle will burn hard porcelain colors with purity from the first. We always have to get it into good condition by firing gold in it two or three times. Sometimes it cannot be perfectly hardened at all, we then have to have recourse to the coating of minium, as in the case of the big muffle above referred to.

We can always fire colors with greater purity in an old muffle than in one that has only been used a few times, but the old muffle is invariably cracked all over, though these fractures are easily mended with clay and by tying the parts together with iron wire, or better still with platinum wire, which does not burn out and does not expand to any appreciable extent. The muffle should be preserved, so long as we can prevent the smoke entering it by way of the cracks.

Before or during the setting, the ware should be dried and heated in a drier near the kiln and this must be brought to, and maintained at, a rather high temperature while the setting is going on. Without this precaution the damp which is given off by a cold muffle, or the fuel that is put under the muffle to fire the ware, will condense upon the pieces, if cold, and cover them with moisture, which will be very injurious in various ways. It is even necessary to bring the muffle and the ware that is set in it to a temperature above 100 degrees C., that is to say a temperature above that of boiling water; this is a very important precaution.

The door of the muffle must be very carefully luted at its

base as well as all cracks and fissures, in order that not the least smoke or vapor may get in while firing. The upper part does not need so much care as in consequence of the draft produced by the heat all the vapors enter at the bottom and leave at the top of the muffle.

It has been noticed that colors will be all the purer for being fired in a current of air, if this current of air is pure; that is to say they will be brighter and more glazed than when fired in a perfectly enclosed space; for this reason enamels are fired in an open muffle and if it were not for the well-founded fear of breakage when firing colors on porcelain, this method, which has been used sometimes for small pieces, would give very pure burns.

FUEL AND THE MANAGEMENT OF THE FIRE.

As we are only concerning ourselves here with firing the best sort of work we restrict the fuels to three kinds, charcoal, wood and coal.

CHARCOAL.—The use of charcoal has been almost entirely abandoned, although it seems to give the colors more purity and glaze, but since it has been found that, with well constructed kilns, with good draft and thoroughly dry wood, which is reduced by splitting two sticks of a few centimetres in thickness, we obtain a sharp and clear fire, by means of which the most delicate and valuable works of art can be burned as well as we can wish, we have rid ourselves of the inconveniences of charcoal. The use of charcoal has the disadvantage that charging the kiln is very fatiguing to the kiln man, it produces a penetrating dust, it fires up in a way that cannot be calculated and, in large muffles, the inequality of the heat is very difficult to control; finally it makes fractures more frequent and more to be feared. Nevertheless we may use this fuel for firing small pieces, which we wish to, and can without danger, subject to a sharp and quick fire. When using this fuel the fire box or furnace must be spacious and the muffle should be surrounded on all parts by the charcoal, which must be equally light throughout. I do not think very much of this method of firing, although it was practiced at Sevres for many years and by means of it pieces were fired that were of the highest importance, both for the size and as

works of art. I will content myself with quoting here the
practice of firing with charcoal as employed at the imperial
manufactory, of Vienna, where it is done with remarkable
simplicity and despatch. The muffle, about three decimetres
(12 in.) in height is extremely simple, it is placed on a sup-
port in the furnace and completely surrounded with the quanti-
ty of charcoal required for the burn. The charcoal (pine wood
coal) is in very large pieces, it is held up by two pieces of terra
cotta, forming a species of hollow walls that are removable.
The door of the muffle is simply set in its place and is not
luted. There is a view hole in the middle of the door, this is
the only one and an opening for evaporation in the top of the
muffle, but there are no other openings. The illustration
shows one which I saw at Vienna and which was operated
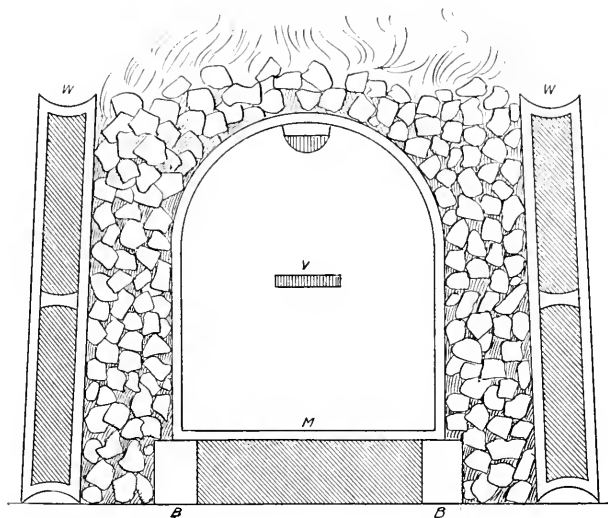
FIRING WITH CHARCOAL.

in my presence, taking only an hour and a half for the burn.
M is the muffle with its door, at the upper part of this is an
opening for the escape of vapors produced by the essences;

V is the view hole; B B are bricks upon which the muffle stands; W W are side walls of hollow terra cotta which keep the charcoal in place around the muffle.

The charcoal is lighted at top by some pieces of wood and in an hour to an hour and a half, according to the size of the ware, the paintings are fired. The burner watches the color of the heat, seen through the view hole of the muffle door and, as soon as it is concluded that this is enough, the hollow terra cotta walls are thrown down, the burning charcoal is pulled away and the muffle is allowed to cool.

This rapidity in firing and in cooling off proves that the ware must possess in a very high degree the property of re- sisting rapid changes of temperature.

Wood.—To fire wih wood the wood should burn with a long and vivid flame. White wood, such as poplar, birch and deal (fir) is preferable to hard wood. It should be very dry and split into small pieces, more or less fine, according to the size of the furnace of the muffle and the season of the year. The firing of large muffles is commenced particularly when they contain voluminous and fragile pieces of ware, with the larger size pieces of wood, the fire is quickened with the fine wood and is finished with the medium sized; this course is pursued in order to be able to judge the fire and to avoid the remount or cumulative effect of the fire.

When we use a fuel that produces a great quantity of heat in a short time, as charcoal does, and when we have to urge the fire in order to bring the colors to a flowing state to make them brilliant, we get a remount, as we call it. that is to say when the firing is done and we draw all the fuel from the fur- nace, whether incandescent wood, or charcoal, and the furnace is quite cleaned out, there is nothing at all to produce heat and yet the temperature of the muffle continues to increase and in- creases very perceptibly; as much as 15 degrees of the silver pyrometer in a quarter of an hour. This is what we call the remount. It is all the stronger in proportion as the fire has been urged rapidly. This phenomenon may be explained in a manner that, it appears to me, is in agreement with all the facts observed.

The heat can only enter the muffle, to reach the ware con- tained in it, by traversing its walls. If we imagine the thick-

ness of these walls to be divided into two layers, it must be admitted that the exterior layer, the one that is in immediate contact with the heat of the furnace, possesses a considerably higher temperature than the interior layer has, and that when the pyrometer shows 260 degrees inside the muffle, if it were possible to put it on the outside it would indicate, perhaps, 290 degrees. Now at the moment when we remove the fuel, that is to say we take away all heat producing material, the outer part of the muffle possesses the elevated temperature we have supposed. The accumulated heat distributes itself by radiating in every direction to those points where the temperature is lower. Thus the 30 degrees of excess that we have supposed, will be divided between the outer space of the furnace and the interior portion of the muffle. Fifteen degrees will be lost on the outside and the other 15 degrees will be added to the 260 degrees of the interior of the muffle, allowing the necessary time for the heat to travel. It takes about a quarter of an hour for the 15 degrees to raise the pyrometer to 275 degrees, although the fire in the furnace has been extinguished during that time. These figures are only given as examples, but they are very nearly correct.

This remount varies from a number of causes, the most potent of which is the rapidity with which the last moments of firing has been done. Thus I have constantly observed that if the silver pyrometer rose by 2 degrees per minute the remount would be strong and would attain the 15 degrees before mentioned. If towards the end of the burn the fire is allowed to slacken the remount is very much reduced or is scarcely noticed.

Coal.—Attempts have been made to burn colors on hard porcelain by means of coal, but when using this fuel it is very difficult to distribute the heat equally in every part of a large muffle and above all, to prevent a little of the smoke getting into the muffle. As the smoke from coal will spoil nearly all the colors and as, in this case the loss is much greater than the saving from the difference in price of the two fuels, the certainty of the wood fire has been preferred to the doubtful chances of the coal.

In any case it is important that the firing should be conducted with regularity, slowly at first and very rapidly to-

wards the end. That which is called a languishing fire may fix
the colors, but it will not gloss them; they are dull, sometimes
even matt. Fourmy has given a good explanation of this and
has proved his explanation by the observation of some appro-
priate facts. When a glass is kept in a state of fusion and
at the same degree of temperature for a certain time, its ele-
ments combine in a different manner, it devitrifies, it crystal-
lizes and becomes opaque. Reaumur's porcelain is only a glass
which has been held for a long time at one temperature and
has become devitrified. It is necessary, in order to bring it
back to the state of a transparent glass, to subject it to a
much higher temperature than that which it has experienced.
This fact explains why, in consequence of a languishing fire,
it is impossible to give a gloss to painting on porcelain that
has come out matt or dull from the muffle, at least without
firing it again and giving it a very much greater heat than at
first, but when we do this we alter the colors and if the paint-
ing is a work of art the piece becomes imperfect.

JUDGING THE FIRE.—There are three means of judging the
fire, that is to say of presuming to what degree of tempera-
ture it has been carried, but none of these is absolutely reli-
able.

In the first, which is not the most uncertain, but which de-
pends entirely upon the individual, the conclusion is drawn
from the color of the fire. A skillful burner, who has a great
amount of practice, will rarely make a mistake, but this power
of judging is altogether a personal quality, which cannot be
transferred to anyone else.

The second, which is the most used, because it is available
for a larger number of people who can easily acquire the habit
of using it, is that of test or trial pieces. These are pieces of
ware which are touched with a color that will change its tint
in a definite manner according to the degree of temperature
to which it is exposed. These little morsels of pottery used
as trial pieces are burned in the muffle along with the painted
goods.

At Sevres and in the majority of the ateliers for firing paint-
ed porcelain, the color that is used for this purpose is carmine,
which is made from the purple of Cassius as described on page
38.

This color is painted on a small piece of porcelain and introduced in the middle of the muffle by means of an iron wire; under the influence of the different degrees of heat it takes the following tints:

1. In the fire that is known as "gold on tender ground" it becomes a reddish brown, dirty, brick-red, color with scarcely any gloss.

2. In the fire called "retouching" it is of a fine rose tint, where the color is thin and rather brick-like in the thick places.

3. In the fire called "first painting" it becomes a rose color inclined to purple.

4. In the fire called "gold on white" it is a rose, with a slight inclination to violet.

5. In the fire for "fillets of gold" or for the substantial gilding for the borders of plates, it takes a violet tint, which becomes more and more pale and deteriorates in proportion to the increase of temperature to which it is exposed.

6. In the "matt gold" fire, the rose tint and even the violet tint, have almost completely disappeared.

These are the principal tints, but they are linked together by a number of intermediate shades.

A multitude of causes, apparently very slight, have an influence independent of the temperature, upon the variations of tint which this delicate color is capable of taking. In the first place, the manner in which it is ground, more or less finely, in the water or oil used as a medium and the quantity, more or less, of fat oil. Then the way in which it is used. Touches of the same carmine, but laid on in different ways by different painters, although burned together and, consequently at the same temperature, will show different tints. It is affected by:

The thickness of the touch; in the same touch of color the thicker part has a rather bricky tint, entirely different to the thin part.

The impurity of the fire, that is to say a disengagement of vapor or of smoke produced by a smothered fire, will cause this color to pass from rose to a dirty violet, from glossy to dull, with a dull gray aureole.

The duration of the fire, without increase of temperature, produces notable alterations in the color.

To make this method as exact and as generally useful as possible I took the following steps, which it may be worth while to describe.

The first carmine, to be used for trial pieces or pyroscopes, was made by the chemist of the works in 1818. A considerable quantity of it (420 grams) was made at once. After having tried it a sufficient number of times to be sure that it was suitable, that is to say, that it was easy to use and was extremely sensitive to changes of temperature, it was accepted, but as this color is altered by the action of damp air, the mass was divided in a number of bottles that were* hermetically sealed. The contents of these bottles, as they were brought into use ,were again subdivided in small, well corked bottles, each of which contained only 10 grams of carmine. Only one bottle was in use at a time for making the trial pieces that were in daily use for firing the colors. The tests were, so far as possible, touched with the carmine by one man, who knew how to use the color; they were marked, first with the date of the delivery of the carmine, then with the date on which they were used and the number of the muffle.

This date, the number, the description of the principal pieces contained in the muffle and the results of the firing, were entered in a record book, read in the presence of the persons responsible for the firing and signed by the superintendent.

In this way, if it is desired to know in what fire a certain piece was burned, on any day during the years that have elapsed since 1818, it can be found immediately, along with the remark that was made respecting the work at the time.

To carry on, through a long series of years, this method of judging the burns, when the carmine for the tests was nearly used up another quantity was prepared and used for several months along with the first lot. The new carmine was not accepted until it was found that two touches, one of the old the other of the new carmine, laid on the same trial piece by the same artist and burned were identically similar in all the heats.

The third method would be much more exact if it could be brought to perfection. This is the pyrometer. I have de-

scribed in another place the conditions that have to be fulfilled
for measuring high temperatures, the difficulties in securing
these and the attempts to overcome them. These difficulties
are not so great for firing, painting or gilding. The expansion
of fine silver, which does not melt at the highest temperature
used for firing muffle colors, can be easily employed and gives
results that are absolute and constant. It is a metal that can
be obtained in a state of perfect purity and with always the
same structure; it remains unchanged in an incandescent heat;
finally, among the metals endowed with these qualities it is the
most dilatable, that is it possesses the greatest ratio of expan-
sion. No other metal could be found to reunite more complete-
ly the necessary conditions, the sole disadvantage restricting
its use is that its melting point prevents its employment for
higher temperatures. It was therefore this metal that I select-
ed in 1805 for the construction of the pyrometer at Sevres, used
for indicating the progress of the firing and the temperatures
corresponding to the degrees of burning of the colors indicated
by the changes of color of the gold carmine. The instrument
consists of a bar of fine silver, two decimetres (8 in.) long,
which is placed in the interior of the muffle among the ware to
be burned, it is put in through the view hole V, shown in our
illustration of the muffle kiln. The expansion of the bar
should indicate the degree of heat in the muffle. In order that
we can measure this expansion outside the muffle the bar of
silver is fitted into a groove in a piece of unglazed hard porce-
lain. One end of the bar butts against a stop in the groove so
that the whole of the expansion shows itself at the other end,
here it presses against a rod of hard porcelain biscuit, of the
same kind as the piece in which the bar is fitted and by means
of this rod an index is moved. The whole arrangement is con-
trived so as to multiply by 100 the movement of expansion of
the bar of silver. The free end of the index travels over an arc
of a circle that is divided into 300 parts; from 27 to 30 of
these degrees are equivalent to 100 degrees of the centigrade
thermometer.

In firing colors upon porcelain we have a latitude from 200
degrees to 280 degrees. Between about 300 degrees and 325
degrees of the pyrometer the silver melts, it is for this reason
that I said that the maximum heat for firing vitrifiable colors

in a muffle or reverberatory kiln was not very far removed from the melting point of silver.

It will be seen that this instrument is very imperfect, because it does not give absolute measures of temperature, but only shows the difference between the expansion of a bar of silver 20 centimetres in length and that of a bar of hard porcelain biscuit of equal length. Now we do not know what the expansion of the porcelain is, all that we know is that it is very small. We therefore have nothing but the difference between two numbers, only one of which is certain.

Firing fixes the vitrifiable colors and, in melting them, gives them transparency and brilliancy. When they are applied upon a glaze which does not affect them no other change takes place, but this passing from the opacity of the unfired colors to the transparent, or at least, translucid, condition of the burned in colors, reduces their intensity and, sometimes, slightly changes their tint. This may destroy the harmony of a painting and diminish its vigor, we therefore have to strengthen the colors by applying a new coat, refire it and, sometimes, again retouch it and fire it a third time. The heat required at each firing will be less, this diminution results from this, that at each retouching we put on a thinner coat of color and that which is below facilitates the fusion of what is on top, but a frequent repetition of the same temperature may change those colors that have been subject to it. Nevertheless we have seen several cases where valuable paintings have passed through the fire five times that were not satisfactory in the first firings, but at the fifth firing acquired all the qualities wished for.

INFLUENCE OF THE MATERIAL UPON WHICH THE COLOR IS LAID.

The nature of the surface upon which the color is applied exercises a marked influence upon the tint that the color preserves after firing. The chemical action of the glaze gives rise to some remarkable results and the relative physical properties of the material upon which the color is laid and the color itself often cause defects that it is necessary for us to be in a position to explain in order to be able to remedy them.

Even the paste of which the body is formed may have some influence upon the colors as we found in the case of a kaolin from Ebreuil. It was noticed that no color prepared from gold

and, above all carmine, preserved its brightness and tint, when laid upon porcelain that had this kaolin for a base.

CHEMICAL INFLUENCE OF THE MATERIAL.

As has already been shown when treating of the glazes, these consist of silicic acid, boracic acid, soda or potash, oxide of lead, and, sometimes, oxide of tin.

Oxide of lead, which is indispensable for certain colors, is injurious to others. For instance, we may cite the colors made from gold, to which it gives a dirty appearance, making them dull and with an inclination to violet, when the flux for these colors already contains the lead needed for fusion.

A similar remark applies, also, to an excess of alkali. When potash and soda are sometimes necessary for the production of fine colors they become the source of more than one defect if, dominating in the glaze of the ware, they react upon the coloring oxides, particularly if the glaze is fusible and we have to fire the color at a high temperature.

Chrome oxide, from its tendency under the influence of potash or of soda, to pass to the state of yellow chrome, offers a striking instance of the trouble that may be caused by a surface that is too alkaline when chrome greens are laid on it. On these glazes and bodies the greens made from chromium are decomposed, they become yellow and the yellow tint even spreads beyond the place where the original green was laid on. Those enamels which owe their fusibility to boracic acid do not exhibit this defect.

Finally, oxide of tin, which enters into the composition of earthenware glazes, gives to these glazes an opacity, which, if the glazes are fusible, will affect the vitrifiable colors and alter their properties; they will become opaque and will not mix properly in consequence of the oxide of tin which they contain.

These short remarks, which it will be easy to amplify by means of those made in treating of each color by itself, will show the importance of possessing a chemical knowledge of the glazes that we intend to decorate, although, as we have seen, this becomes of less importance if the heat at which we have to fire the colors does not have to be so high as to soften the glaze.

The expansion of the glaze upon which the color is applied
and that of the glaze itself, are, in certain respects, intimately
related. It is necessary that the two materials should expand
in about the same ratio, in order that, in cooling, their con-
traction will be alike. This is a knowledge which it is im-
possible to acquire by reasoning out from theory, we can only
get at it by trying.

A difference in the expansion ratio of the ground and of the
color produces defects that it is almost impossible to remedy,
therefore it is most important that we should be on our guard
to prevent this, the result of which will often appear at the
third time of firing the color. We even have examples of
paintings which have "molted" a long time after leaving the
muffle.

"Crazing" and "molting" are defects that are frequently in-
dependent of the firing, when this has been brought to the
proper point; these faults are more often due to a bad compo-
sition, to bad preparation of the color. On examining a chip
from a piece that has "molted" we can easily see that the
piece that flew off carried with it a notable portion of the sur-
face of the ware upon which it had been attached.

The colors that are applied upon very fusible glazes, partic-
ularly upon tender porcelain, never exhibit this defect, what-
even their ratios of expansion may be. The melting of the
glaze causes the flux of the color to melt, thus establishing
an equilibrium between the glaze and the vitrifiable color, be-
coming in this way almost identical they expand uniformly
and forming, practically, but one substance, the whole con-
tracts equally together.

INFLUENCE OF SURROUNDING VAPORS DURING BURNING.

The vitrifiable colors are exposed during firing to other in-
fluences besides that of the glaze upon which they are laid.
Even if they are protected from the action of smoke and ashes
from the fire they will be still subject to the influence of the
vapor of water, of carbonic oxide, of alkaline and plumbi-
ferous vapors. It is as well to understand the part these ploy
and the energy of their action. The muffle in which we set

the most delicate ware will, sometimes, be accidentally affect-
ed by vapors whose presence leaves traces upon the ware,
which are very often ineffaceable.

THE VAPOR OF WATER.—Water in the condition of vapor only,
will not do any harm to vitrifiable colors, provided the tem-
perature is suitably and regularly raised, so as to prevent con-
densation. Experiments several times repeated, upon painted
pieces that were plunged into water before firing, confirms this
opinion.

Humidity cannot have any other action upon a painting
in the muffle, but a mechanical one; it acts by condensing on
the colors and the drops of water running over the surface
displace them. We have gone fully into the details of how to
prevent this when setting the ware.

We have said that the vapor of water alone will not have
any effect upon the colors, but this is not at all the case
when the vapor of water is mixed with carbonic oxide, it
augments the decomposing energy of this agent, as has been
proved by Malguti's experiments.

Theory only attributes to carbonic oxide a reducing action
upon the lead oxide contained in the flux; Malguti's experi-
ments have taught us that a flux will not lose in weight if
kept at a white heat for four hours in a current of dry air, nor
even in a current of moist air; neither does it lose any of its
weight when brought to a state of incandescence in an atmos-
phere formed of equal parts of air, hydrogen and carbonic
oxide, provided the mixture is dry; the reduction commenced
so soon as the mixture became moist. Upon analysis it was
found that the loss was solely in the oxide of lead contained
in the flux.

Is the reduction of the oxide of lead and the volatilization of
the metal after it is reduced the sole cause of the dull appear-
ance which vitrifiable colors often exhibit? Is it only the
presence of moist carbonic oxide, in the smoke, that com-
municates its destructive properties? We do not think so.

SMOKY AND ACID VAPORS.

No smoke will prevent the colors being bright, nor will soot
itself, mixed with the flux, do this, provided it is burned off
before reaching a red heat; very often we mix the blacks,

which do not have their full tint when laid on, a fairly strong proportion of lamp black, without preventing the vitrifiable black taking a good gloss. Carbon vapors may enter a muffle without any risk of spoiling the burn, but wood smoke has entirely different chemical characteristics, because it is strongly charged with empyreumatic oils and pyroligneous acid, which act in an entirely different manner, these are what poison the muffle and they poison, perhaps, less by means of the carbonic oxide than by the small quantity of acid principles that they contain.

This explanation appears to us to be supported by the action of sulphurous acid upon the colors in the muffle. It is generally known that it is impossible to fire colors properly in a muffle in which copper (sulphate of iron)has been calcined and that it is of the greatest importance to thoroughly wash the reds, made from sulphate of iron, in boiling water; an imperfect washing prevents them taking a gloss and the small quantity of acid that they contain will react upon the other colors.

It now remains for us only to consider the influence of the plumbiferous and acid vapors.

FLUXING VAPORS.

We have spoken of the volatilization of oxide of lead and pointed out the conditions, which, fortunately, are very rare, when this volatilization takes place.

We should add to this that if we put a piece of ware covered with a lead glaze near a piece which is not glazed the glazed piece will lose its gloss while the biscuit will show the commencement of glazing. This fact explains the practice which manufacturers pursue, of coating the inside of the muffles with litharge, in which they burn their lead glazed ware.

This should impress upon us the importance of the precautions to be taken in setting art paintings in the kiln. The lead vapors, sucked in, so to say, enter into combination with the silica contained in the substance upon which they condense and if this is colored with colors prepared from gold the gold colors will be at once changed by a flux containing too much lead, they will certainly be spoiled and become a dirty violet. Fine stoneware is covered with a thin, but sufficiently thick,

glaze by simply burning it along with pieces charged with lead oxide.

ACCIDENTS AND LOSSES.

After having described in this work all means and processes employed for decorating ceramic ware in a substantial manner and suitable to its mineral nature, before concluding, we should examine the alterations and injurious changes that sometimes accompany these methods and the way to avoid them, or at least, to correct them.

We will examine in succession the defects and losses that come from the fire, those that may be attributed to the materials used for decorating and finally the alterations that may be produced in these materials, which may be caused by various agencies after they are fixed on the ware by the fire.

CHANGES RESULTING FROM THE ACTION OF THE FIRE.

The first is that which the colors suffer from through an excess of heat. They lose their vigor, they run together, they react the one upon the other, the most refractory colors, such as the blue, the green, the blacks, resist and become dominant; the others, such as the pinks, the grays, change color or disappear; the reds pass over to dark brown and the browns to black. When this excess of heat is extreme there is no remedy, but if complete decomposition has not taken place we may attempt to remove those colors that are too much changed, in order to replace them by new colors and then refire the piece. It is very seldom that this succeeds if the piece has been much over fired, where all the colors are more or less changed and it becomes necessary to give it a second, or worse still, a third firing.

If the painting has been under fired the colors will be matt, the gold will not hold on. It would naturally suggest itself to us that firing it again at a higher temperature would be an easy and efficacious remedy, but this is not always the case, at least for those colors that have become harder, for the increased temperature that we are compelled to give them alters the delicate colors without giving a fine gloss to the hard colors. We can only approach success by giving these that are matt through insufficient fire, a thin glaze of their own color.

The best way to correct this fault depends upon the cir-

cumstances and must be left to the judgment of the practiced workman. It is a matter that concerns the person who prepares the colors and the one in charge of the firing and the painter or decorator cannot be blamed for a loss of this kind.

ALTERATIONS RESULTING FROM THE COLORS OR FROM THEIR USE.

We will suppose that the colors are good and have only been accepted, as is the practice at Sevres, after being carefully tested and submitted to the examination of the various classes of painters who will have to use them; after this their qualities are discussed in a reunion of the painters, in the presence of the director of the works and the chemist who prepares the colors, if then they are admitted to be capable of giving good results, when properly used, either alone or mixed in suitable proportions with the colors with which they may be associated, they are accepted. If, when they are used, they give poor results, this can only be caused by the fire, which is easily recognized, or else it is due to the ignorance of the painter, or from want of sufficient care in the use of the colors, that is to say in grinding or mixing them, the thickness with which they are laid on, the choice of the medium, etc.

Thus, putting on one side the changes that may occur through bad qualities in the colors as we will suppose that only good ones are accepted, we have no other faults to fear than the following:

Molting, which may be caused by too high a temperature, by laying on too great a thickness of color, or by an incorrect mixing. We have explained what was meant by the technical expression "molting" and what might be the cause in relation to the color itself. Here we can only consider it as due to one of the two causes we have just mentioned and in such case, particularly from the second cause, when it is the fault of the painter, this only shows itself in certain directions and may be met by attending to the instructions we are about to give. But if the defect is the result of over firing, or of an improper use of the colors over the whole piece, the attempted remedy is not only useless, but aggravates the evil, for the heat necessary to burn the new parts will change the neighboring portions and even make them molt.

Molting is a very serious fault and one that robs a vitrifiable painting of, what I venture to call its greatest merit, that of defying the action of time, for it matters little, in an art production, even of simple ornament, that only a part of it is spoiled; it must be complete and perfect or else it would have done just as well and would have been less expensive, to have made the entire picture with the permanent color which had to be used to repair the moltings.

The pieces, decorated with ornament, that molt and are not intended for domestic or other rough use, may be repaired with non vitrifiable colors, rendered fairly durable and resistant to cold water by mixing with copal varnish. The piece will have its full effect and preserve it for a long while, though it will have lost its value as a perfect piece, but this method of repairing molting cannot be tolerated on ware that is to be used for table service, for after a very little use the mended portions will disappear through the effect of rubbing, washing in hot water, etc.

There are two methods of making repairs which we will describe.

The oldest method is the local and circumscribed removal of the part that has to be relaid. Formerly a piece of hard burned stone ware, called green stone or water stone, was used, with this the defective color was removed by grinding it off, but the operation was long and it was difficult to remain within the limits of the color to be removed, besides this the rough and uneven surface produced, communicates this roughness to the color that is laid on the ground-off spot.

The practice now is to use hydrofluoric acid, particularly at Sevres, where this method was employed for the first time by Willermet. We know with what care this very corrosive acid must be handled; we take a brush, dipped in the acid more or less diluted, and pass the brush over the color, this dissolves, and it is removed in much the same way that a lead pencil mark is effaced by rubbing it with a piece of caoutchouc. The ware must be immediately washed in a full flow of water, several times repeated, it must then be perfectly dried, for we must make quite sure that no trace of the hydrofluoric acid remains, which would be capable of spoiling all the colors in the muffle.

The place where the glaze has been cleaned off by this simple operation remains smooth; it hardly loses its gloss and the retouch is made and attaches itself perfectly.

The dullness which some colors exhibit, side by side with good, bright, glossed colors, presents a very disagreeable want of harmony. When this is only partial it can come from no other cause than an improper mixture of a color that is too hard, with the principal color, for the purpose of modifying its tint.

This defect may be corrected by refiring, first laying on a thin coat of the color containing a more fusible flux; several refirings may be necessary. If success cannot be attained this way the only other resource is to attempt to remove the disagreeable matt surface by polishing it by friction.

A want of gloss that comes from a defect in the color which did not show itself when it was tested before acceptance, or which the examiner overlooked, is more likely to be found in azure blue. After glazing in the first fire it devitrifies in the second and becomes dull and even coarse grained. This is a defect which, as will be seen, does not come under any of our categories and can only be avoided by putting a glaze of the same blue, for the second fire, upon that which has already been burned.

Want of harmony results from an improper use of the colors and above all from the mixing; when one color has had a greater effect upon another than the artist anticipated, it destroys, more or less completely, the tint of the one upon which it has been placed. I can cite a striking example of this alteration in a very valuable piece of ware, where a gray flux, laid on some portraits of dark complexioned men, to give a gray shade to the chins, bleached all the places where it was put on.

If the piece has not been over fired and the accident happens in the first firing, retouching will correct it completely, but at a final firing it is better to leave the fault which, often, can then only be detected by a skillful and careful observer.

A fault which is as serious and is somewhat analagous to molting, is that known as the creeping of a color, it appears to be similar, for muffle colors, to that which the blue shows in the sharp fire. The color gathers together in little streaks,

leaving white places that look like moltings, but it can be distinctly seen that the color has drawn away and gathered together in places which have become thickened and melted into small lumps, they have not lifted off as in molting. This fault is due to the artist having used essence that has become too fat from the action of the air. When distilled essence is used this never happens. The defect shows itself more frequently in summer than in winter. As a rule it happens only in the first firing so that it is easily corrected. The portions of color that have crept together are removed and the surface is repainted.

Another defect, of which we neither know the cause nor the cure, is where a painting in the first fire becomes covered with a multitude of minute black specks, this seldom happens in the second firing, it has been attributed to a reduction of the oxide of lead of the flux. We have noticed that it is not distributed equally over the whole surface of the piece upon which the plumbiferous colors had been applied, and that sky blues and carnation grays were more subject to it than the other colors, also that the spots were often more abundant on the prominent portions of a glaze that was not evenly laid and some times these minute spots were only in those parts. This fault may also be met with on the enamel of faience.

There is always the hope of causing it to disappear in the second firing, but this hope is not always realized, in which case the piece is entirely spoiled.

When a piece, such as a vase or a painting, has one or two colors in it that remain dull in the midst of brilliant colors, we may diminish this disagreeable effect by giving them something of a gloss by polishing them. The polishing material consists of pulverized glaze and the tool upon which it is spread is a piece of soft wood, the rubbing surface of which is cut and shaped to a suitable form. The very finely powdered glaze is placed on the end of the stick and the dull portion is rubbed hard until it shows a slight glaze.

Various substances have been tried, such as tripoli, pumice powder, emery powder, etc.; some are too hard, others are too soft. The glaze has a medium hardness and is very suitable. It acts strongly, without scratching the ware or removing the colors, though there are some colors that are so ex-

tremely thin and tender that, when they become dull, no at-
tempt at polishing can be made without the risk of rubbing
them off.

ALTERATIONS WHICH TAKE PLACE, FROM VARIOUS CAUSES, AFTER
FIRING.

After pottery has been decorated and the pieces have been
fired successfully, they are by no means completely secure
from damage. They must be capable of receiving the liquids,
which they are destined to contain, without being affected by
these in any way. Now, there are some of the food acids,
such as vinegar, the juice of apples, or lemon juice, even when
sweetened with sugar, that will affect certain of the hard
porcelain colors when in contact with them for 10 or 12 hours.
The colors that are the most susceptible to these changes are
those that have the brightest tints, such as the turquoise blue
No. 23 and the gold colors, above all the carmine, which even
the vapor of water will sometimes attack. The following
colors, though less susceptible are liable to be affected; they
are: Reddish gray, No. 13; iridium black, No. 20; yellow
ochre, No. 50 A; the late red 64 and violet red 66; the iridium
black and the reds 64 and 66 will have to be in contact with
the vegetable acid for about 24 hours before they are affected.
The colors that are affected by the action of the vapor of
water are very much more rare and among these, of the gold
colors, we should only include carmine. We can test the col-
ors for this susceptibility beforehand, by exposing them for 24
or 30 hours to the vapor of boiling water. Water in the liquid
state, even when hot, does not produce the same effect. This
action of the vapor of water was very curiously illustrated in
the case of a painted glass window that was made at Sevres
in 1829, and placed in the sacristy of Notre-Dame-de-Lorette,
at Paris. After the window had been in position in the newly
built church for one or two years, the rose colored and pale
purple glass, stained with purple precipitate of gold and an
alkaline flux, appeared as if they were partly washed away by
the moisture which condensed upon the windows. People
hastened to say that the modern stained glass was not equal to
the ancient, without stopping to think that the old masters,
whose much harder colors sometimes change too, never used

rose and purple colors made from gold, which they had no knowledge of. It was so far as I knew then, the first time that these colors had been used for painted windows, though I found, afterwards, that they had been used in some of the modern windows in a chapel at the university of Oxford. Here, too, on the occasion of a visit in 1836 I saw that the colors were deteriorating.

The rose and purple glass in the church window at Paris was taken out and replaced by harder, though less beautiful, colors. Before putting them in place they were submitted to the action of the vapor of boiling water, so as to be quite sure that they were proof against it. But what caused us to note the difference in the action of water and its vapor was that among the pieces of stained glass was one that did not show any sign of change, although it was charged with the same color as the others. On examination it was found that this particular piece of glass had, inadvertently, been put into the frame wrong side out, that is to say that the stained side had been turned outwards and was exposed to the rain so that the water washed over its surface. From this it was evident that the water which frequently flowed over it had less effect upon it than vapor in the interior of the church. There is no other remedy for this defect than to use harder colors and to burn them sharper. If it is impossible to combine the two things then we must sacrifice the brightness of the color to durability, particularly when it is a question of ware that is intended for domestic use; the delicate, tender and brilliant colors, which are liable to change in wear should only be applied as ornament or decoration to pieces that are not subject to the deleterious action of the substances we have mentioned.

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